K.R. MANGALAM UNIVERSITY
THE COMPLETE WORLD OF EDUCATION

(Est. Under the Govt. of Haryana private Universities Act No. 2006, under section 2f of the UGC Act, 1956)

K.R. MANGALAM UNIVERSITY
THE COMPLETE WORLD OF EDUCATION

SCHOOL OF BASIC AND APPLIED SCIENCES (SBAS)

Programme Handbook

Four Year Undergraduate Programme

B.Sc. (Honours with Research) Chemistry

Programme Code: 10
2023-2027

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PREAMBLE

With a steadfast commitment to the transformative principles laid out in the New Education Policy (NEP) [2020], we proudly introduce the B.Sc. (Honours with Research) Chemistry 4-Year Programme. Rooted in the essence of the NEP, this innovative academic journey is tailored to provide students with a profound understanding of the molecular world, critical analytical skills, and a holistic perspective, empowering them to excel in a dynamic global landscape.

The B.Sc. (Honours with Research) Chemistry 4-Year Programme embodies the NEP's vision of fostering a student-centric, flexible, and multidisciplinary approach to higher education. By emphasizing experiential learning, research-driven exploration, and the integration of technology, this programme aspires not only to enhance students' intellectual capacities but also to nurture their practical acumen, ingenuity, and ethical discernment.

Inspired by the NEP's emphasis on a comprehensive curriculum, the B.Sc. (Honours with Research) Chemistry 4-Year Programme offers an array of core courses, electives, and interdisciplinary modules. This approach encourages students to delve deeply into the realm of chemistry while also benefiting from exposure to related disciplines, fostering a holistic outlook and cultivating the ability to synthesize ideas across domains.

Additionally, the NEP's call for research-based education is exemplified in this programme through hands-on laboratory work, research projects, and the cultivation of independent inquiry. By engaging with faculty mentors on advanced research endeavors, students are instilled with a culture of innovation and an inquisitive spirit.

The B.Sc. (Honours with Research) Chemistry 4-Year Programme is intricately woven with the NEP's directive for flexible and personalized learning pathways. Through a credit-based system, students can pursue minor specializations, interdisciplinary concentrations, or even opt for courses from other faculties, granting them a sense of academic autonomy and adaptability.

According NEP Curriculum Framework is

The new curriculum framework will have the following features:

i. Flexibility to move from one discipline of study to another;

ii. Opportunity for learners to choose the courses of their interest in all disciplines;

iii. Facilitating multiple entry and exit options with UG certificate/ UG diploma/ or degree depending upon the number of credits secured;

iv. Flexibility for learners to move from one institution to another to enable them to have multi and/or interdisciplinary learning;

v. Flexibility to switch to alternative modes of learning (offline, ODL, and Online learning, and hybrid modes of learning). 9University Grants Commission 9 Regulations for Academic Bank of Credit (ABC) and guidelines for Multiple Entry and Exit are already in place to facilitate the implementation of the proposed "Curriculum and Credit Framework for Undergraduate Programmes".

All the courses are having defined objectives and Learning Outcomes, which will help prospective students in choosing the elective courses to broaden their skills in the field of Chemistry and interdisciplinary areas. The courses will train students with sound theoretical and experimental knowledge that suits the need of academics and industry. The courses also offer ample skills to pursue research as career in the field of physics. Aligned with the NEP's integration of technology in education, this programme harnesses digital tools and resources to enrich learning experiences, facilitate virtual collaborations, and provide access to a reservoir of knowledge from across the globe.

As we embark on this transformative educational odyssey, we extend an earnest invitation to students, educators, and stakeholders to join us in realizing the vision of the New Education Policy. Through the B.Sc. (Honours with Research) Chemistry 4-Year Programme, we aspire to nurture the next generation of chemists, researchers, and innovators who will shape the advancement of society and contribute to the betterment of humanity.

The K. R. Mangalam University hopes the NEP-2020 approach of this four year under graduate programme B.Sc. (Honours with Research) Chemistry will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

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1. UNIVERSITY VISION AND MISSION

K.R. Mangalam University is the fastest-growing higher education institute in Gurugram, India. Since its inception in 2013, the University has been striving to fulfil its prime objective of transforming young lives through ground-breaking pedagogy, global collaborations, and world-class infrastructure.

Recognized for its virtues of quality, equality, inclusiveness, sustainability, and professional ethics, KRMU is synonymous with academic excellence and innovation.

1.1. VISION

K.R Mangalam University aspires to become an internationally recognized institution of higher learning through excellence in inter-disciplinary education, research and innovation, preparing socially responsible life-long learners contributing to nation-building.

1.2 MISSION

1. Foster employability and entrepreneurship through futuristic curriculum and progressive pedagogy with innovative technology.

2. Instill notion of lifelong learning through stimulating research, outcomes-based education and innovative thinking.

3. Integrate global needs and expectations through collaborative programs with premier universities, research centres, industries, and professional bodies.

4. Enhance leadership qualities among the youth understanding ethical values and environmental realities.

2. School of Basic and Applied Sciences

The school imparts both teaching and research through its various science disciplines viz Mathematics, Chemistry and Physics.

School of Basic and Applied Sciences imparts students' disciplinary knowledge, enhances their skills and ability, motivating them to think ingeniously, helping them to act independently and take decisions accordingly in all their scientific pursuits and other endeavors. It strives to empower its students and faculty members to contribute for the development of society and Nation.

The faculty is in constant touch with various experts in the relevant fields and is willing to experiment with the latest ideas in teaching and research.

Programmes offered by the school

School established in 2013, offers undergraduate B.Sc. (Hons) Programmes, postgraduate M.Sc. Programmes, and Doctoral Programmes. All these programmes are designed to impart scientific knowledge to the students and are aimed at supplying theoretical as well as practical training in their respective fields.

School offers undergraduate B.Sc. (Honours with Research) Chemistry. This program emphasizes on hands on practice, innovative thought processes and project-based learning.

3. SCHOOL VISION AND MISSION

3.1.School Vision

School of Basic and Applied Sciences intends for continuum growth as centre of advanced learning, research, and innovation by giving analytical and scientific knowledge in the areas of basic and applied sciences by promoting interdisciplinary research and scientific acumen.

3.2. School Mission

M1. Enable students to be scientists/ academicians /entrepreneurs by accomplishing fundamental and advanced research in diverse areas of basic and applied sciences

M2. Build strong associations with academic organizations/industries for knowledge creation, advancement, and application of scientific fervor

M3. Create conducive environment for lifelong learning

M4. Empower students to be socially responsible and ethically strong individuals through value-based science education

The school offers programmes in physics, mathematics, chemistry, and forensic sciences.

4. Introduction to B.Sc. (Honours with Research) Chemistry Programme

4.1: Nature of B.Sc. (Honours with Research) Chemistry Programme

The NEP-2020 offers an opportunity to affect change in basic assumptions from a teacher-centric to a student-centric higher education system in India.It is based on Outcome Based Education, where the Graduate Attributes are first kept in mind to reverse-design the Programs, Courses and Supplementary activities to reach the graduate attributes and learning outcomes.The learning outcomes-based curriculum framework for a degree in B.Sc. (Honours with Research) Chemistry is intended to provide a comprehensive foundation to the subject and to help students develop the ability to successfully continue with further studies and research in the subject while they are equipped with required skills at various stages. The framework is designed to equip students with valuable cognitive abilities and skills so that they are successful in meeting diverse needs of professional careers in a developing and knowledge-based society. The curriculum framework considers the need to support globally competitive standards of achievement in terms of the knowledge and skills in Chemistry, as well as to develop scientific orientation, spirit of enquiry, problem solving skills and human and professional values which foster rational and critical thinking in students.

4.2. Aim of B.Sc. (Honours with Research) Chemistry Programme

The programme aims to develop the professional competence among students by providing them with good subject knowledge, experiential learning and research acumen. It strives to equip students with the necessary skills, knowledge, and competencies to effectively identify, plan, deliver solutions of the real world problems.

Progressive Certificate, Diploma, bachelor's degree, or bachelor's Degree with HonoursProvided at the End of Each Year of Exit of the Four-year Undergraduate Programme

EXIT OPTIONS	CREDITS REQUIRED

Certificate upon the Successful Completion of the First Year (Two Semesters) of the multidisciplinary Four-year Undergraduate Programme/Five-year Integrated Master's degree Programme	Min 40
Diploma upon the Successful Completion of the Second Year (Four Semesters) of the multidisciplinary Four-year Undergraduate Programme/Five-year Integrated Master's degree Programme	Min 80
Basic bachelor's degree at the Successful Completion of the Third Year (Six Semesters) of the multidisciplinary Four-year Undergraduate Programme/Five-year Integrated Master's degree Programme	Min120
Bachelor's degree with Honours in a Discipline at the Successful Completion of the Fourth Year (Eight Semesters) of the multidisciplinary Four-year Undergraduate Programme	Min 160

Curriculum Framework for Multidisciplinary Four- year Undergraduate Programme

Year	Objectives	Nature of Courses	Outcome
1styear– (1^{st}&2^{nd} Semesters)	Understanding and Exploration	1. Discipline based Core Courses 2. Minor Discipline 3. Value added course 4. Open Elective 5. Ability Enhancement Compulsory Courses 6. Skill Enhancement	Understanding of Disciplines Language Competency Gaining perspective of context/Generic skills Basic skills related to handling and working with the instruments to pursue any vocation related to Lab Assistant
Exit option with Certification			
2^{nd} Year- (3^{rd} &4^{th} Semesters)	Focus and Immersion	1. Discipline based Core Courses 2. Discipline specific elective Courses 3. Minor Discipline 4. Open Elective 5. Skill Enhancement 6. Ability Enhancement 7. Value added course 8. Internship	Understanding of disciplines Gaining perspective of context Skill sets for employability in data type setter, Development of various domains of mind & Personality
Exit Option with Diploma			

3rd Year- (5th &6th Semesters)	Real time Learning	1. Major Discipline Core 2. Discipline specific elective Courses 3. Minor Discipline 4. Skill Enhancement 5. Value added course 6. Internship	In depth learning of major and minor disciplines, Skill sets for employability. Exposure to discipline beyond the chosen Subject Experiential learning/Research.
Exit option with Bachelor's degree			
4th Year– (7th & 8th Semesters)	Deeper Concentration	1. Major Discipline Core 2. Minor Discipline 3. Research/Project Work with Dissertation	Deeper and Advanced Learning of Major Discipline Foundation to pursue Doctoral Studies & Developing Research competencies
Bachelor's degree Honours with Research			

5. LEARNING OUTCOME-BASED CURRICULUM FRAMEWORK IN 4- YEAR BACHELOR OF SCIENCE (B.Sc.) PROGRAMME WITH RESEARCH

The Learning Outcomes-based Curriculum Framework (LOCF) for the B.Sc. (Honours with Research) Chemistry programme provides a framework for the student-teachers to develop a range of knowledge, skills, attitudes, and values that teachers should possess to meet the educational needs of diverse learners, create an engaging and inclusive learning environment and contribute to the overall improvement of the research system. The curriculum has clearly articulated learning outcomes that describe what students should be able to know, understand, and demonstrate by the end of the programme. It integrates theoretical knowledge with research application and allows for flexibility and adaptation to meet the needs of individual student-teacher. It offers elective courses or specialization options, enabling student-teachers to pursue their areas of interest or specialization within the broader field of education. The curriculum includes various assessment methods and tools to measure the attainment of learning outcomes.

6. GRADUATE ATTRIBUTES OF B.SC. (HONOURS WITH RESEARCH) CHEMISTRY PROGRAMME WITH RESEARCH

B.Sc. (Honours with Research) Chemistry,focuses to cultivate a range of graduate attributes essential for success in various professional domains. Graduates possess a robust foundation in chemical theories, methodologies, and laboratory practices, enabling them to conduct rigorous scientific research.

GA1: Strong Chemical Foundation: Graduates possess a solid understanding of chemical principles, theories, and laboratory techniques, forming the basis for their research endeavors.

GA2: Research Proficiency: The program equips graduates with the ability to design and execute scientific experiments, analyze complex data, and contribute meaningfully to advancements in the field.

GA3: Analytical Acumen: Graduates are skilled in critically evaluating data, identifying patterns, and drawing insightful conclusions, essential for research and problem-solving.

GA4: Problem-Solving Skills: The curriculum nurtures graduates' capacity to tackle intricate scientific challenges, fostering creativity and adaptability in developing innovative solutions.

GA5: Effective Communication: Graduates can proficiently communicate their research findings and scientific concepts to both technical and non-technical audiences, facilitating collaboration and knowledge dissemination.

GA6: Team Collaboration: The program emphasizes teamwork, enabling graduates to collaborate harmoniously with diverse groups and leverage collective expertise.

GA7: Adaptability: Graduates are prepared to navigate evolving scientific landscapes, demonstrating flexibility and openness to incorporating new methodologies and technologies.

GA8: Ethical Awareness: The curriculum promotes ethical research conduct, ensuring graduates approach their work with integrity and a strong sense of responsibility.

GA9: Innovation: Graduates are encouraged to think creatively and explore new avenues, fostering a mindset that drives the development of novel solutions and approaches.

GA10: Career Versatility: Armed with comprehensive skills and knowledge, graduates are equipped for a range of careers, including research positions, academia, industry roles, and scientific communication.

These attributes collectively empower graduates to excel as competent and ethical professionals within the field of chemistry and related sectors.

7. QUALIFICATION DESCRIPTORS FOR B.SC. (HONOURS WITH RESEARCH) CHEMISTRY PROGRAMME

Certainly, here are qualification descriptors that outline the expected outcomes and competencies of a 4-year B.Sc. (Honours with Research) Chemistry program with a research focus:

Knowledge Base: Graduates possess an in-depth understanding of fundamental chemical concepts, theories, and principles. They have a comprehensive grasp of advanced topics in organic, inorganic, physical, and analytical chemistry, enabling them to apply this knowledge in diverse research contexts.

Research Proficiency: Graduates demonstrate proficiency in designing, conducting, and interpreting scientific experiments. They are adept at employing various research methodologies, techniques, and instrumentation to investigate complex chemical phenomena.

Analytical Skills: Graduates exhibit strong analytical skills, capable of critically evaluating experimental data, identifying trends, and drawing meaningful conclusions. They can navigate intricate datasets and employ statistical tools effectively.

Problem-Solving Aptitude: Graduates exhibit the ability to tackle complex scientific challenges, applying creative and systematic approaches to devise innovative solutions. They are adept at formulating hypotheses, designing experiments, and adapting methodologies as needed.

Laboratory Competence: Graduates are skilled in using state-of-the-art laboratory equipment and techniques. They can conduct experiments safely and accurately, adhering to rigorous laboratory protocols and ethical guidelines.

Data Interpretation: Graduates are proficient in analyzing and interpreting experimental results, drawing valid conclusions, and communicating findings through quantitative analyses, graphical representations, and written reports.

Communication Proficiency: Graduates excel in conveying scientific information to diverse audiences. They communicate research findings effectively through written reports, oral presentations, and visual aids, catering to both technical peers and non-experts.

Ethical Awareness: Graduates demonstrate a strong ethical foundation, adhering to ethical standards in research conduct, data handling, and interactions with colleagues. They exhibit integrity and accountability in their scientific pursuits.

Collaborative Skills: Graduates excel in collaborative environments, engaging in interdisciplinary teamwork and effectively contributing their expertise to group projects and research initiatives.

Innovation and Adaptability: Graduates showcase adaptability to emerging technologies and methodologies. They embrace a spirit of innovation, pursuing new approaches and methodologies to address complex scientific challenges.

Critical Thinking: Graduates exhibit critical thinking skills, evaluating scientific literature, identifying gaps in knowledge, and formulating research questions that contribute to advancing the field of chemistry.

Career Readiness: Graduates are well-prepared for various career paths, including research and development positions, advanced studies in chemistry or related fields, teaching roles, and roles in scientific communication.

These qualification descriptors capture the multifaceted skills, knowledge, and attributes that graduates of a 4-year B.Sc. in Chemistry program with a research focus should possess, positioning them for success in a range of professional and academic pursuits.

8. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: To provide students with a comprehensive understanding of the core principles and advanced concepts in chemistry.

PEO2: To cultivate a culture of research among students by involving them in research projects, to contribute to scientific knowledge and innovation.

PEO3: To develop students' practical skills to conduct experiments, analyze data, and apply theoretical concepts in laboratory settings.

PEO4: To develop students with analytical and problem-solving skills to evaluate chemical problems, devise innovative solutions, and contribute to scientific advancements.

PEO5: To encourage students to explore connections between chemistry and other disciplines, promoting interdisciplinary collaboration to address complex global challenges.

PEO6: Instill ethical values and sustainable practices in chemical research and applications, empowering students to consider environmental implications while advancing scientific knowledge.

PEO7: To prepare graduates for a variety of career pathways, including academia, industry, research, and entrepreneurship.

1. PROGRAMME OUTCOMES (POs)

PO1: To acquire a strong grasp of core chemistry concepts and theories across diverse areas.

PO2: To develop research skills to design, conduct, and contribute to scientific investigations.

PO3: To demonstrate interdisciplinary approachby applying chemistry's connections to other fields.

PO4: To analyze complex chemical problems, devise innovative solutions, and evaluate scientific literature.

PO5: To demonstrate ethical conduct in research, considering safety and societal impact.

PO6: To communicate scientific ideas clearly through oral and written presentations.

PO7: To apply creativity and entrepreneurial thinking to translate chemistry into practical applications.

PO8: Societal Contribution: Utilize chemistry knowledge to address real-world challenges, aligning with NEP's goals.

PO9: Share research findings through publications and presentations.

PO10: Exhibit leadership qualities and ethical conduct in research and collaboration.

2. PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1: To attain a comprehensive and structured grasp of the foundational principles and theories in various sub-disciplines of Chemistry.

PSO2: To develop practical knowledge and practical skills relevant to diverse professions within the field of Chemistry.

PSO3: To cultivate specialized skills within chosen areas of Chemistry, while staying abreast of contemporary advancements, research, and emerging trends in the field.

PSO4: To demonstrate adeptness in applying chemical knowledge and associated technologies, contributing to problem-solving, innovation, and practical applications in various domains.

MAPPING OF SCHOOL VISION, MISSION WITH PROGRAMME OUTCOMES (PO) AND PROGRAMME SPECIFIC OUTCOMES (PSO) OF B.Sc. (Honours with Research) Chemistry

School Vision	School Mission	Programme Outcomes (PO)	Programme Specific Outcomes (PSO)
School of Basic and Applied Sciences intends for continuum growth as centre of advanced learning, research and innovation by disseminating analytical and scientific knowledge in the areas of basic and applied sciences by promoting interdisciplinary	M 1	PO2, PO4, PO9	PSO1, PSO3, PSO4
	M 2	PO1, PO3, PO5	PSO2, PSO4

research and scientific acumen.	M3	PSO3	PO6, PO8
	M 4	PO5, PO10	PSO2
	M5	PO1	-

11. Programme Duration

The duration of the program will vary from one to four years depending on the choice of student.

12. CAREER AVENUES

- **Research Scientist**
- **Academic Researcher**
- **Pharmaceutical Industry**
- **Chemical Analyst**
- **Materials Scientist**
- **Environmental Scientist**
- **Forensic Scientist**
- **Quality Control Specialist**
- **Science Communication**
- **Consulting**
- **Government Agencies**
- **Industrial Research**
- **Product Development**
- **Health and Safety Officer**
- **Entrepreneurship:**

These career avenues highlight the versatility and breadth of opportunities available to graduates with a B.Sc. in Chemistry and a research focus. Tailoring your skills and interests to these options can lead to a fulfilling and impactful career.

13. ELIGIBILITY CRITERIA

B. Sc. (Hons.) Chemistry with Research

This course aims to impart basic and applied knowledge in various branches in Chemistry with a view to produce good academics, researchers and professionals in the field.The student should have passed the 10+2 examination conducted by Central Board of Secondary Education or equivalent examination from a recognized Board in Science stream with an aggregate of 50% or more.

Course Outline: -Inorganic chemistry / Organic chemistry / Physical chemistry / Analyticalmethods in chemical sciences / Environmental chemistry / Biochemistry / Green Chemistry.

14. CLASS TIMINGS

The class will be held from Monday to Friday from 9.10 A.M. to 4.00 P.M.

15. TEACHING- LEARNING PROCESS

The School of Basic and Applied Sciences brings an attitudinal change among prospective teachers for their advancement into accountable agents of change in society. They are actively engaged in undertaking different activities during their course with systematic support and feedback from the faculty. During this program, the students will be involved in participation and organization of various curricular, co-curricular, extra curricular and extension and outreach activities. Such practices bring experiential learning by emphasizing creativitity and finding exposure and solution for social issues. The faculties foster and maintain a creative environment with a deep commitment to inculcate excellence in academics and contribute to student development through a focus on student-centric methods such as experiential learning, participative learning, problem-solving and ICT integration in the teaching-learning process.

16. ASSESSMENT METHODS

Both formative and summative assessments are integral part of the B.Sc. programme.Formative assessments such as class discussions, group activities, projects, quizzes, assignments and presentations are conducted throughout the teaching-learning process, enabling teachers to monitor student progress continuously.Teachers provide oral or written feedback, engage in one-on-one discussions, and use rubrics and checklists to communicate student performance.Summative assessments such as Term End Examination, viva voce for project work, research dissertations and performance evaluations are conducted after the completion of the course.

17. MINIMUM ACCEPTABLE LEVEL OF ACADEMIC STANDARDS

The minimum acceptable level of achievement that a student must demonstrate to be eligible for the award of academic credit or qualification is the minimum acceptable level of academic standards. The Letter Grades and Grade Points which shall be used to reflect the outcome of the assessment process of the student's performance is indicated in Table 1.

Table 1

Marks Range (%)	Letter Grade	Grade Points	Description of the Grade
>90	O	10.0	Outstanding
80-90	A+	9.0	Excellent
70-80	A	8.0	Very Good
60-70	B+	7.0	Good
55-60	B	6.0	Above Average
50-55	C	5.5	Average
40-50	P	5.0	Pass

<40	F	0	Fail
-	AB	0	Absent
% marks≥ 50	S	-	Satisfactory
% marks <50	US	-	Unsatisfactory
	W	0	Withdrawal

18. PROGRAMME STRUCTURE

B.Sc. (Honours with Research) Chemistry- Undergraduate Programme

Semester	I	II	III	IV	V	VI	VII	VIII	Total
Credits	23	26	24	21	22	16	14	16	162

19. Scheme of Studies for B.Sc. (Honours with Research) Chemistry

The syllabi of B.Sc. (Honours with Research) Chemistry for all years offered by SBAS with course structure are given in the following pages.

B.Sc. (Honours with Research) Chemistry	Year 2023-2027 (Scheme of Studies)														SBAS		
YEAR	ODD SEMESTER									EVEN SEMESTER							
	S. No.	COURSE CODE	COURSE TITLE	L	T	P	C	TYPE OF COURSE		S. No	COURSE CODE	COURSE TITLE	L	T	P	C	TYPE OF COURSE
FIRST	1	SCCH101	INORGANIC CHEMISTRY-I	3	1	0	4	MAJOR		1	SCCH102	PHYSICAL CHEMISTRY-I	3	1	0	4	MAJOR
	2	SCCH151	INORGANIC CHEMISTRY-I PRACTICALS	0	0	4	2			2	SCCH152	PHYSICAL CHEMISTRY-I PRACTICALS	0	0	4	2	
	3	SCCH103	ORGANIC CHEMISTRY-I	3	1	0	4	MAJOR		3	SCCH104	ORGANIC CHEMISTRY-II	3	1	0	4	MAJOR

	4	SCCH153	ORGANIC CHEMISTRY-I PRACTICALS	0	0	4	2		4	SCCH154	ORGANIC CHEMISTRY-II PRACTICALS	0	0	4	2	
	5	AEC001	NEW AGE LIFE SKILLS-I	3	0	0	3	AEC-I	5	AEC002	NEW AGE LIFE SKILLS-II	3	0	0	3	AEC-II
	6	SEC007	GROUNDWATER MODELLING	2	0	0	2	SEC-I	6	SEC008	DATA ANALYSIS AND VISUALIZATION	2	0	0	2	SEC-II
	7		MINOR I	4	0	0	4	MINOR I	7		MINOR II	4	0	0	4	MINOR II
	8	VAC151	VAC I	2	0	0	2	VAC I	8		OPEN ELECTIVE-I	3	0	0	3	OE-I
									9		VAC II	2	0	0	2	VAC II
										* Internship will be of 4-6 weeks duration at the end og Semester II during summer break and the evaluation will be done during Semester III						
	TOTAL						**23**				**TOTAL**				**26**	
	ODD SEMESTER								**EVEN SEMESTER**							
SECOND	1	SCCH201	PHYSICAL CHEMISTRY-II	3	1	0	4	MAJOR	1	SCCH202	PHYSICAL CHEMISTRY-III	3	1	0	4	MAJOR
	2	SCCH251	PHYSICAL CHEMISTRY-II PRACTICALS	0	0	4	2		2	SCCH252	PHYSICAL CHEMISTRY-III PRACTICALS	0	0	4	2	
	3	SCCH203	ORGANIC CHEMISTRY-III	3	1	0	4	MAJOR	3	SCCH204	INORGANIC CHEMISTRY-II	3	1	0	4	MAJOR
	4	SCCH253	ORGANIC CHEMISTRY-III PRACTICALS	0	0	4	2		4	SCCH254	INORGANIC CHEMISTRY-II PRACTICALS	0	0	4	2	
	5	AEC003	NEW AGE LIFE SKILLS-III	3	0	0	3	AEC-III	5	SEC009	OPEN SOURCE WARE IN GIS AND REMOTE SENSING	2	0	0	2	SEC-III
	6		OPEN ELECTIVE-II	3	0	0	3	OE II	6		MINOR IV	4	0	0	4	MINOR IV
	7		MINOR III	4	0	0	4	MINOR III	7		OPEN ELECTIVE-III	3	0	0	3	OE III

	8	SICH001	INTERNSHIP/ PROJECT	0	0	0	2	INTERNSHIP			* Internship will be of 4-6 weeks duration at the end og Semester IV during summer break and the evaluation will be done during Semester V						
		TOTAL					**24**				**Total**					**21**	
	ODD SEMESTER									**EVEN SEMESTER**							
THIRD	1	SCCH 301	INORGANIC CHEMISTRY-III	3	1	0	4	MAJOR		1		DISCIPLINE ELECTIVE COURSE-I	3	1	4	4	MAJOR
	2	SCCH 351	INORGANIC CHEMISTRY-III PRACTICALS	0	0	4	2			2		DISCIPLINE ELECTIVE COURSE-I PRACTICALS	0	0	4	2	
	3	SCCH 303	INTRODUCTION TO QUANTUM CHEMISTRY	3	1	0	4	MAJOR		3	SCCH302	ORGANIC SPECTROSCOPY	3	1	0	**4**	MAJOR
	4	SCCH 353	INTRODUCTION TO QUANTUM CHEMISTRY PRACTICALS	0	0	4	2			4		MINOR VI	4	0	0	4	MINOR VI
	5		MINOR V	4	0	0	4	MINOR V		5		VAC IV	2	0	0	2	VAC IV
	6	SEC010	INTELLECTUAL PROPERTY RIGHT (IPR) AND BUSINESS SKILLS FOR CHEMISTS	2	0	0	2	SEC-IV									
	7	SICH002	INTERNSHIP/PROJECT	2	0	0	2	INTERNSHIP									
	8		VAC III	2	0	0	2	VAC III									
	TOTAL						**22**			**TOTAL**						**16**	
	ODD SEMESTER									**EVEN SEMESTER**							
FOURTH	1		DISCIPLINE ELECTIVE COURSE-II	3	1	0	4	MAJOR		1	SCCH402	RESEARCH PROJECT	0	0	0	12	
	2		DISCIPLINE ELECTIVE COURSE-II PRACTICALS	0	0	4	2			2		MINOR VIII	4	0	0	4	MINOR VIII
	3	SCCH 401	RESEARCH METHODLOGY	4	0	0	4	MAJOR		3							

	4		MINOR VII	4	0	0	4	MINOR VII		4							
	TOTAL						14			TOTAL						16	

DISCIPLINE SPECIFIC ELECTIVE- I					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
SCCH304	MEDICINAL CHEMISTRY	3	1	0	**4**
SCCH356	MEDICINAL CHEMISTRY PRACTICALS	0	0	4	**2**
SCCH306	HETREOCYCLIC CHEMISTRY	3	1	0	**4**
SCCH358	HETREOCYCLIC CHEMISTRY PRACTICALS	0	0	4	**2**
SCCH308	INTRODUCTION OF NANOCHEMISTRY AND APPLICATIONS	3	1	0	**4**
SCCH360	INTRODUCTION OF NANOCHEMISTRY AND APPLICATIONS PRACTICALS	0	0	4	**2**
SCCH310	GREEN PROCESSES OF CHEMISTRY	3	1	0	**4**
SCCH362	GREEN PROCESSES OF CHEMISTRY PRACTICALS	0	0	4	**2**

DISCIPLINE SPECIFIC ELECTIVE -II					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
SCCH403	ADVANCE MATERIAL CHEMISTRY	3	1	0	**4**
SCCH455	ADVANCE MATERIAL CHEMISTRY PRACTICALS	0	0	4	**2**
SCCH405	ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY	3	1	0	**4**
SCCH457	ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY PRACTICALS	0	0	4	**2**
SCCH407	POLYMER CHEMISTRY	3	1	0	**4**
SCCH459	POLYMER CHEMISTRY PRACTICALS	0	0	4	**2**
SCCH409	ENVIRONMENTAL CHEMISTRY	3	1	0	**4**
SCCH461	ENVIRONMENTAL CHEMISTRY PRACTICALS	0	0	4	**2**
SCCH411	ANALYTICAL TECHNIQUES OF CHEMISTRY	3	1	0	**4**
SCCH463	ANALYTICAL TECHNIQUES OF CHEMISTRY PRACTICALS	0	0	4	**2**

POOL OF ENVIRONMENTAL SCIENCE AS MINOR						
S.No.	**COURSE CODE**	**COURSE TITLE**	**L**	**T**	**P**	**C**
MINOR I	UEV101	EARTH AND EARTH SURFACE PROCESSES	4	0	0	4

MINOR II	UEV102	HYDROLOGY AND HYDROGEOLOGY	4	0	0	4

SCCH101	Inorganic Chemistry – I	L	T	P	C

MINOR III	UEV103	NATURAL RESOURCES MANAGEMENT AND SUSTAINABILITY	4	0	0	4
MINOR IV	UEV104	NATURAL AND ANTHROPOGENIC HAZARDS	4	0	0	4
MINOR V	UEV105	ENVIRONMENT LEGISLATION POLICIES AND ESG'S	4	0	0	4
MINOR VI	UEV106	WASTE MANAGEMENT	4	0	0	4
MINOR VII	UEV107	ENVIRONMENTAL IMPACT ASSESSMENT AND RISK ASSESSMENT	4	0	0	4
MINOR VIII	UEV108	SDG'S AND CLIMATE CHANGE	4	0	0	4

Syllabi of Courses to B.Sc. (Honours with Research) Chemistry

Semester-I

Version 3.0		**3**	**1**	**0**	**4**
Total Contact Hours	**60**				
Pre-requisites/Exposure	**Basics of atoms and bonding in molecules**				
Co-requisites	**-**				

Course Objectives

1. To provide knowledge about basic concepts of atomic structure and bonding.
2. To learn the various properties of elements in periodic table
3. To study about the ionic and covalent bonding in compounds and general characteristics
4. To enable the students competently matters of metallic bonding and weak chemical forces

Course Outcomes

On completion of this course, the students will be able to

CO1. Remember fundamental concepts related to atoms and their structure.

CO2. Understand the principles governing atomic structure.

CO3. Apply knowledge of bonding theories to predictmolecular geometries and properties.

CO4. Analyze complex molecules and determine their bonding patterns.

CO5. Evaluate the relationship between atomic structure and chemical reactivity.

CO6. Create new models or theories to explain observed chemical phenomenon.

Catalog Description

In this course students will learn about the structure of atom on the basis of different theories like Bohr's atomic theory, Planck's quantum theory, de – Broglie equation and Heisenberg's uncertainty principle. Students will learn about the orbitals in atom their size, shape, orientation and periodic properties. This course helps them to get idea about the VSEPR, VBT and MOT theories of chemical bonding and crystal structures. This will also provide information of metallic and van'der Waals bonds.

Course Content

UNIT I: Atomic Structure **15 Lectures**

Bohr'stheory,itslimitationsandatomic spectrumofhydrogenatom.Wavemechanics:de'Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of $\psi 1$and $\psi 2$. Quantum numbers and their significance.Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals, Contour boundary and probabilitydiagrams.Pauli'sExclusionPrinciple,Hund'sruleofmaximummultiplicity,Aufbau's principle and its limitations, Variation of orbital energy with atomicnumber.

UN IT II: Periodicity of Elements **15 Lectures**

s, *p*, *d*, *f*block elements, the long form of periodic table. Detailed discussion of the following properties of the elements with reference to *s* and*p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodictable.

(b) Atomic radii (van'derWaals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral andtetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affectingionization energy. Applications of ionizationenthalpy.

(f) Electron gain enthalpy, trends of electron gainenthalpy.

(g) Electronegativity, Pauling, Mullikan, Allred Rachow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity. Sanderson electron densityratio.

UNIT III: Chemical Bonding **15 Lectures**

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations.Packingofionsincrystals.Born-Landéequationwithderivation,expressionforlattice energy.Madelung constant, Born-Haber cycle and its application, Solvationenergy.

(i) *Covalent bond:* Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapesofsimplemoleculesandionscontaininglone-andbond-pairsofelectronsmultiplebonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear andheteronucleardiatomicmolecules,MOdiagramsofsimpletriandtetra-atomicmolecules,e.g., N_2,O_2,C_2,B_2,F_2,CO,NO,andtheirions;HCl,BeF_2,CO_2,HCHO,(ideaofs-pmixingandorbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability,Fajanrules,polarization.Ioniccharacterincovalentcompounds:Bondmoment and dipole moment. Ionic character from dipole moment andelectronegativities.

UNIT IV: Metallic bonding and Weak chemical forces **15 Lectures**

(ii) *Metallic Bond:* Qualitative idea of free electron model, Semiconductors,Insulators.

(iii) *Weak Chemical Forces:* van'der Waals, ion-dipole, dipole-dipole, induced dipole dipole-induced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility,dissolution.

Text Books

1. Lee, J. D. Concise Inorganic Chemistry, Wiley, 5th Edn.

Reference Books/Materials

1. Douglas, B.E., McDaniel, D.H., Alexander J.J., Concepts & Models of Inorganic Chemistry, (Third Edition) John Wiley & Sons, 1999.
2. Atkins, P. W. and DePaula, J. Physical Chemistry, Tenth Edition, Oxford University Press, 2014.
3. Rodger, G. E. Inorganic and Solid-State Chemistry, Cengage Learning, 2002.

Open Educational Resources (OER)

- https://www.t.soka.ac.jp/chem/iwanami/intorduct/ch02structure.pdf
- https://www2.chemistry.msu.edu/courses/cem151/chap7lect_2009.pdf
- https://authors.library.caltech.edu/105209/6/TR000574_01_chapter-1.pdf
- https://ncert.nic.in/textbook/pdf/kech104.pdf
- https://www.youtube.com/watch?v=f5bLO2nx1dE&list=PLeO0gXBrQL63QPgzoT9PGwVJqpd7jDgCd
- https://kanchiuniv.ac.in/coursematerials/Mrs.%20KI%20-%20Chemical%20Bond.pdf
- https://www.youtube.com/watch?v=f5bLO2nx1dE&list=PLeO0gXBrQL63QPgzoT9PGwVJqpd7jDgCd

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Attendance	Quiz/Assignment/ Presentation	Mid Term Examination	End Term Examination
Weightage (%)	10	20	20	50

Programme and Course Mapping

Course Code and Title	Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2	PSO 3	PSO 4
SCCH101 Inorganic Chemistry – I	CO1	3		3	2	2						3			
	CO2		3			3								3	
	CO3	2		3								3			
	CO4	3		3										2	
	CO5		3	2								3			
	CO6	3		3			2					3		1	

1=lightly mapped 2= moderately mapped 3=strongly mapped

Unit I	Atomic Structure
Local	-
Regional	-
National	-
Global	Orbitals in atom their size, shape, orientation and periodic properties.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	**Periodicity of Elements**
Local	-
Regional	-
National	-
Global	*s*, *p*, *d*, *f* block elements, the long form of periodic table
Employability	-
Entrepreneurship	-

Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Chemical Bonding
Local	-
Regional	-
National	-
Global	VSEPR, VBT and MOT theories of chemical bonding and crystal structures
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Metallic bonding and Weak chemical forces
Local	-
Regional	-
National	-
Global	Metallic bonding and Weak chemical forces
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Scholarships for Higher Education 4b,
NEP 2020	India’s ; India's Higher Education System (9.1- 9.3) Prepare students for more meaningful and satisfying lives (9.1.1)
POE/4th IR	Effective and sustainable learning required for employability/ Learning of structure of compounds with basic concepts which helps them in higher education and research

Teaching Plan:

Weekly Teaching Plan	**Topic/Unit No.**	**Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ Open Education Resources [OER]**	**Teaching-Learning Method**
Week 1	**Unit 1:** Bohr'stheory,itslimitationsandatomicspectrumofhydrogenatom.Wavemechanics:de'Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of $\psi 1$and $\psi 2$. Quantum numbers and their significance.	**TB-1/ RB-3/ OER-1**	Group Discussion/Presentation
Week 2	**Unit 1:** Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals,	**TB-1/ RB-3/ OER-1/2**	Group Discussion/Presentation
Week 3	**Unit 1:** Contour boundary and probabilitydiagrams.Pauli'sExclusionPrinciple,Hund'sruleofmaximummultiplicity,Aufbau's principle and its limitations, Variation of orbital energy with atomicn umber.	**TB-1/ RB-3/ OER-1/2**	Group Discussion/Presentation
Week 4	**Unit 2:** *s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and*p*-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodictable	**TB-1/ RB-1/ OER-3**	Group Discussion/Presentation
Week 5	**Unit 2:**(b) Atomic radii (van'derWaals)	**TB-1/ RB-**	Group

	(c) Ionic and crystal radii. (d) Covalent radii (octahedral andtetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionizationenthalpy	**1/OER-3/4**	Discussion/Presentation
Week 6	**Unit 2:** (f) Electron gain enthalpy, trends of electron gainenthalpy. (g)Electronegativity, Pauling, Mullikan, Allred Rachow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity. Sanderson electron densityratio.	**TB-1/ RB-1/OER-3/4**	Group Discussion/Presentation
Week 7	**Unit 3:** Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations.Packingofionsincrystals	**TB-1/ RB-1/OER-4**	Group Discussion/Presentation
Week 8	**Unit 3:** Born-Landéequationwithderivation,expressionforlattice energy. Madelung constant, Born-Haber cycle and its application, Solvationenergy.	**TB-1/ RB-3/OER-4/5**	Group Discussion/Presentation
Week 9	**Unit 3:** *Covalent bond:* Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapesofsimplemoleculesandionscontaining lone-andbond-pairsofelectronsmultiplebonding, sigma and pi-bond approach	**TB-1/ RB-3/OER-5**	Group Discussion/Presentation
Week 10	**Unit 3:** Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy	**TB-1/ RB-3/OER-4/5**	Group Discussion/Presentation
Week 11	**Unit 3:** Molecular orbital theory. Molecular orbital diagrams of simple homonuclear andheteronucleardiatomicmolecules.MOdiagramsofsimpletriandtetra-atomicmolecules,e.g., N_2,O_2,C_2,B_2,F_2,CO,NO,andtheirions	**TB-1/ RB-3/OER-4/5**	Group Discussion/Presentation

Week 12	**Unit 3:**MOdiagramsofHCl,BeF_2,CO_2,HCHO,(ideaofs-pmixingandorbital interaction to be given).Covalent character in ionic compounds, polarizing power and polarizability,Fajanrules,polarization.Ioniccharacterincovalentcompounds:Bondmomentand dipole moment. ionic character from dipole moment andelectronegativities.	**TB-1/ RB-3/OER-5**	Group Discussion/Presentation
Week 13	**Unit 4:** *Metallic Bond:* Qualitative idea of free electron model, Semiconductors,Insulators.	**TB-1/ RB-3/OER-5/7**	Group Discussion/Presentation
Week 14	**Unit 4:** *Weak Chemical Forces:* van'der Waals, ion-dipole, dipole-dipole, induced dipole dipole- induced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility,dissolution	**TB-1/ RB-3/OER-6/7**	Group Discussion/Presentation
Week 15	**Revision**	**TB-1/RB-3**	Group Discussion/Presentation

Facilitating the Achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching Learning Activity**	**Assessment Task Methods**
1	A comprehensive understanding of atomic strcuture and different theories with limitations	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Identify trends in periodic table such as the increase or decrease of properties across periods and down groups. Illustrate how changes in atomic structure affect periodic trends and reactivity		
3	A comprehensive understanding of concepts related to chemical bonding, from fundamental		

SCCH151	Inorganic Chemistry-I Practicals	L	T	P	C
Version 3.0		0	0	4	2
Total Contact Hours	30				
Pre-requisites/Exposure	12^{th} level practices and experiments				
Co-requisites	--				

	theories to practical applicationsto analyze and predict bonding patterns, understand the forces that hold molecules together		
4	Understanding of metallic bond and van'der Waals forces		

Course Objectives

1. To familiarize the students with solution preparations and calibration of apparatus.
2. To enhance expertise of students in acid-base and redox titrations for quantitative analysis.

Course Outcomes

CO1. Understand principles and concepts underlying titration techniques.
CO2. Apply appropriate calculations to determine the concentration of an analyte in a sample.
CO3. Analyze experimental data and calculate the volume and concentration of reactants.
CO4. Evaluate the accuracy and precision of the obtained results.
CO5. Create Report for the experiment

Catalog Description

This course imparts the understanding of quantitative analysis by titration method to find out the concentrations of unknown salt or ions present in solution. This course helps them to get experience of preparing primary and secondary standard solutions with different normality and molarity. This course also introduces the calibration of apparatus and oxidation-reduction titrations..

Course Content

(A) Titrimetric Analysis

(i) Calibration and use ofapparatus.

(ii) Preparation of solutions of different Molarity/Normality oftitrants.

(iii) Use of primary and secondary standardsolutions

(B) Oxidation-ReductionTitrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$solution.

(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(iii) Estimation of Fe(II) with $K2Cr_2O_7$using internal (diphenylamine, anthranilic acid) and external indicator.

(C) Acid-BaseTitrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in amixture.

(iii) Estimation of free alkali present in differentsoaps/detergents

Text Books

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* Sixth Edition, Pearson,2009.

Reference Books/Materials

1. O. P. Pandey, D.N. Bajpai, S.Giri, Practical chemistry, S. Chand & Company Pvt. Ltd.
2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Open Educational Resources (OER)

- https://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXI/chemistry/kelm206.pdf
- https://www.youtube.com/watch?v=dLNsPqDGzms&pp=ygUTQWNpZC1CYXNlVGl0cmF0aW9ucw%3D%3D
- https://www.ramauniversity.ac.in/online-studymaterial/pharmacy/bpharma/isemester/pharmaceuticalanalysis-i/lecture-8.pdf
- https://www.youtube.com/watch?v=hZxP-Qdm55s&pp=ygUdT3hpZGF0aW9uLVJlZHVjdGlvblRpdHJpbWV0cnk%3D

- https://www.youtube.com/watch?v=5rtJdjas-mY&pp=ygUdT3hpZGF0aW9uLVJlZHVjdGlvblRpdHJpbWV0cnk%3D
- https://faculty.ksu.edu.sa/sites/default/files/unit_11_-_redox_titrations_-_subjects_1_0.pdf
- https://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXII/chemistry/lelm106.pdf

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	**Conduct of Experiment**	**Lab Record/Quizzes/ Viva-Voce**	**Attendance**	**End Term Practical Examination**
Weightage (%)	**20**	**20**	**10**	**50**

Programme and Course Mapping

Course Code and Title	**Course Outcome**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
SCCH151 Inorganic Chemistry-I Practicals	**CO1**	3				3						3			
	CO2		3											2	
	CO3	3												3	
	CO4		3			3						2			
	CO5	3				3								3	

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Method
Week 1	Calibration and use of apparatus	**RB-2/OER-I/2**	**Discussion and Experiment**
Week 2	Preparation of solutions of different Molarity/Normality of titrants Use of primary and secondary standard solutions	**RB-2/OER-1/2**	**Discussion and Experiment**
Week 3	Estimation of carbonate and hydroxide present together in mixture	**RB-2/OER-2**	**Discussion and Experiment**
Week 4	Estimation of carbonate and bicarbonate present together in a mixture	**RB-1/2/OER-3**	**Discussion and Experiment**
Week 5	Estimation of free alkali present in different soaps/detergents	**RB-2/OER-3/4**	**Discussion and Experiment**
Week 6	Estimation of free alkali present in different soaps/detergents	**RB-2/OER-4**	**Discussion and Experiment**
Week 7	Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$solution	**RB-2/OER-4/5**	**Discussion and Experiment**
Week 8	Estimation of oxalic acid and sodium oxalate in a given mixture.	**RB-2/OER-4**	**Discussion and Experiment**
Week 9	Estimation of Fe(II) with $K_2Cr_2O_7$using internal (diphenylamine, anthranilic acid) indicator	**RB-2/OER-5**	**Discussion and Experiment**

Week 10	Estimation of Fe(II) with $K_2Cr_2O_7$using external indicator	**RB-2/OER-5/6**	**Discussion and Experiment**
Week 11	Revision		**Discussion and Experiment**
Week 12	Revision		**Discussion and Experiment**
Week 13	Revision		**Discussion and Experiment**
Week 14	Revision		**Discussion and Experiment**

Facilitating the Achievement of Course Learning Outcomes

For Example:

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Gain valuable hands-on experience in working with advanced materials and the associated equipment and techniques.	(i) Each experiment to be explained with illustrations. (ii) Students to be encouraged to analyse the concentration of compounds using analytical methods (iii) Introduce students to quantitative analysis techniques to find ouit the concentration of ions present in a given sample. (iv) Stu Conduct titration experiments involving different types of internal and external indicators.	• Experiment Performance and class discussions. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Develop critical skills required for scientific research, such as experimental design, data analysis, and effective communication of scientific findings.		

SCCH103	**Organic Chemistry-I**	L	T	P	C
Version 3.0		3	1	0	4
Total Contact Hours	**60**				
Pre-requisites/Exposure	Basics introduction of organic chemistry				
Co-requisites	--				

Course Objectives

1. The course is infused with the recapitulation of fundamentals of organic chemistry and the introduction of a new concept of visualizing the organic molecules in a three-dimensional space.
2. To establish the applications of these concepts, the functional groups- alkanes, alkenes, alkynes and aromatic hydrocarbons are introduced.
3. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Course Outcomes

On completion of this course, the students will be able to

CO1. Understand and explain the different nature and behavior of organic compounds based on fundamental concepts learnt.

CO2. Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.

CO3. Learn and identify many organic reaction mechanisms including Free Radical Substitution, Electrophilic Addition and Electrophilic Aromatic Substitution.

CO4. Understand the fundamental concepts of stereochemistry.

CO5. Analyze the basic difference between aliphatic and aromatic compounds.

CO6. Creation of logic behind organic chemistry.

Catalog Description

This course comprises of basics of organic chemistry, which involves concept of hybridization, various Electronic Displacements, reaction intermediates. Concept of stereochemistry is discussed. Aliphatic and aromatic hydrocarbons are also included, with preparation, physical properties and chemical properties.

Course Content

UNIT I

Basics of Organic Chemistry **15 Lectures**

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity andbasicity;Types,shapeandrelativestabilitiesofreactionintermediates(Carbocations,Carbanions, Free radicals andCarbenes).Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

UNIT II

Stereochemistry **15 Lectures**

Conceptofasymmetry,FischerProjection,NewmannandSawhorseprojectionformulaeandtheir interconversions;Geometricalisomerism:cis–transand,syn-antiisomerismE/ZnotationswithC.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixtures, Relative and absolute configuration: D/L and R/S designations.

UNIT III

Chemistry of Aliphatic Hydrocarbons **15 Lectures**

A. Carbon-Carbon sigmabonds

Chemistryofalkanes:Formationofalkanes,WurtzReaction,Wurtz-FittigReactions,Freeradical substitutions: Halogenation - relative reactivity andselectivity.

B. Carbon-Carbonpi-bonds

Formationofalkenesandalkynesbyeliminationreactions,MechanismofE1,E2,E1cbreactions.Saytzeff and Hofmann eliminations.Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration- demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2- and 1, 4- addition reactions in conjugated dienes and, Diels-Alderreaction;Allylicandbenzylicbrominationandmechanism,e.g.propene,1-butene,toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilicadditions.

C. Cycloalkanes and ConformationalAnalysis

Cycloalkanes and stability, Baeyer strain theory, Conformation analysis, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms.

UNIT IV

Aromatic Hydrocarbons **15 Lectures**

Aromaticity: Huckel’s rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocycliccompoundswithsuitableexamples.Electrophilicaromatic substitution halogenation,nitration, sulphonation and Friedel-Craft’s alkylation/acylation with their mechanism.Directing effects of substituent groups.

Recommended Books/References:

1. Bahl and Bahl, Advanced Organic Chemistry, S. Chand Publication House.

2. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).
3. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill,(2007)
4. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
5. J.Clayden,N.Greeves,S.Warren,OrganicChemistry,2ndEd.,(2012),OxfordUniversitiy Press.
6. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher,(2000).

Open Educational Resources (OER)

Organic Chemistry - Basic Introduction - Bing video

Complete Hydrocarbons | Day 2 | Organic Chemistry in 7 Days | Maha Yuddh | NEET | Nitesh Devnani - Bing video

Introduction to chirality | Stereochemistry | Organic chemistry | Khan Academy - Bing video

Aromatic Hydrocarbons | L 25 | Master Organic Chemistry | NEET 2023/2024 | Nitesh Devnani - Bing video

Assessment & Evaluation

Components	Quiz/Assignme	Mid Term	Attendance	End Term
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course Code and Title	Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2	PSO 3	PSO 4
SCCH103 Organic Chemistry-I	CO1	3	3	2	3		2		2		3	3	1		2
	CO2	3	3	2	3		2		2		3	3	1		2
	CO3	3	3	2	3		2		2		3	3	1		2
	CO4	3	3	2			2	2		2		3	2	3	2
	CO5	3	3	2	3		2	3	2		3	3	1		2

	CO6	3	3	2	3	3	2	3	2	3	3	3	1	3	2

1=weakly mapped

2= moderately mapped

3=strongly mapped

Unit I	Basics of Organic Chemistry
Local	-
Regional	-
National	-
Global	Organic reactions and their mechanism: Addition, Elimination and Substitution reactions
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	Stereochemistry
Local	-
Regional	-
National	-
Global	D/L and R/S designations.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Chemistry of Aliphatic Hydrocarbons
Local	-

Regional	-
National	-
Global	Formationofalkenesandalkynesbyeliminationreactions
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Aromatic Hydrocarbons
Local	-
Regional	-
National	-
Global	Aromaticity: Huckel's rule,
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Universal quality education and lifelong learning (SDG4-4.4)
NEP 2020	Quality Universities and Colleges: A New and Forward-looking Vision for India's; India's Higher Education System (9.1-9.3) Towards a More Holistic and Multidisciplinary Education (11.1- 11.13)
POE/4th IR	Technical Skills that match Industry Needs/Skill Embedded Courses Development (eg: Chemical analyst, researcher)Online tool to understand molecular structures/reactions

Teaching Plan:

Weekly Teaching	**Topic/Unit No.**	**Textbook [TB]/ Reference Book**	**Teaching-Learning Method**

Week 1	Basics of Organic Chemistry/Unit I	**TB1-1**	Lecture, Discussion
Week 2	Basics of Organic Chemistry/Unit I	**TB1-1/TB1-2**	Lecture
Week 3	Basics of Organic Chemistry/Unit I	**TB1-2/TB1-3**	Lecture
Week 4	Basics of Organic Chemistry/Unit I	**TB1-2/TB1-3**	Lecture, Problem solving
Week 5	Stereochemistry/Unit II	**TB1-4**	Lecture, Discussion
Week 6	Stereochemistry/Unit II	**TB1-4**	Lecture
Week 7	Stereochemistry/Unit II	**TB1-4**	Lecture
Week 8	Stereochemistry/Unit II	**TB1-4**	Lecture, Problem solving
Week 9	Chemistry of Aliphatic Hydrocarbons/Unit III	**TB1-6**	Lecture, Discussion
Week 10	Chemistry of Aliphatic Hydrocarbons/Unit III	**TB1-6**	Lecture
Week 11	Chemistry of Aliphatic Hydrocarbons/Unit III	**TB1-6**	Lecture
Week 12	Chemistry of Aliphatic Hydrocarbons/Unit III	**TB1-6**	Lecture, Problem solving
Week 13	Aromatic Hydrocarbons/Unit IV	**TB1-29**	Lecture, Discussion
Week 14	Aromatic Hydrocarbons/Unit IV	**TB1-29**	Lecture

Week 15	Aromatic Hydrocarbons/Unit IV	**TB1-29**	Lecture
Week 16	Aromatic Hydrocarbons/Unit IV	**TB1-29**	Lecture, Problem solving

Facilitating the Achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching Learning Activity**	**Assessment Task Methods**
	Students will classify compounds and explain their nomenclature. They'll grasp hybridization's impact on bond properties, understand electronic displacement effects, and analyze dipole moments. Students will comprehend curly arrow rules, formal charges, electrophiles, and nucleophiles. They'll identify reaction intermediates and understand addition, elimination, and substitution mechanisms.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
	Students will understand projection formulae, differentiate isomerism types, and apply CIP rules for configurations. They'll explain optical activity, enantiomers, and absolute configurations.		
	Students will learn about sigma and pi bonds, mechanisms of alkane reactions, elimination reactions, and addition reactions of alkenes. They'll grasp concepts of cycloalkanes, Baeyer strain theory, and conformational analysis.		
	Students will understand aromaticity, aromatic compounds' characteristics, and mechanisms of electrophilic aromatic substitution. They'll learn about directing effects of substituents.		

	Organic	L	T	P	C

SCCH153	**Chemistry-I Practicals**				
Version 3.0		0	0	4	2
Total Contact Hours	30				
Pre-requisites/Exposure	Basics of reaction mechanism				
Co-requisites	--				

Course Objectives

1. To enable the student for hands on learning by experiments.
2. To generate confidence among students to perform reactions or analysis.

Course Outcomes

On completion of this course, the students will be able to

CO1. Understand the calibration of instruments.

CO2. Evaluate the boiling points and melting points correctly.

CO3. Understand the chromatographic techniques.

CO4. Analyze the separation of mixture.

CO5. Learn about purification of substances.

CO6. Learn about the environment safety at the time of performing experiment.

Catalog Description

This course provides information regarding Calibration of instruments, Purification of organic compounds and determination of boiling points, melting points of organic compounds. Chromatographic techniques (TLC) are the important part this course.

Course Content

1. Cecking the calibration of thethermometer.
2. Purification of organic compounds by crystallization using the followingsolvents:
   a.Water b. Alcohol c. Alcohol-Water
3. Purification by Distillation, Decolouration (Charcoal treatment) and Sublimation.
4. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting pointapparatus).
5. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.
6. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillarymethod)
7. Chromatography

- Separation of a mixture of two amino acids by ascending and horizontal paperchromatography
- Separation of a mixture of two sugars by ascending paperchromatography
- Separation of a mixture of *o*-and *p*-nitrophenol or o-and p-aminophenol by thin layer chromatography(TLC).

Recommended Books/Reference:

1.Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson (2012)
3. O.P. Pandey, Practicals of Chemistry, Laxmi Publication.
(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Compone	**Conduct of**	**Lab Record/Quizzes/**	**Attendanc**	**End Term**
Weighta	**20**	**20**	**10**	**50**

Programme and Course Mapping

Course Code	**Course Outco**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
SCCH153 Organic Chemistry-I Practical	**CO1**	**3**	**3**	**2**	**3**		**2**		**2**		**3**	**3**	**1**		**2**
	CO2	**3**	**3**	**2**	**3**		**2**		**2**		**3**	**3**	**1**		**2**
	CO3	**3**	**3**	**2**	**3**		**2**		**2**		**3**	**3**	**1**		**2**
	CO4	**3**	**3**	**2**			**2**	**2**		**2**		**3**	**2**	**3**	**2**
	CO5	**3**	**3**	**2**	**3**		**2**	**3**	**2**		**3**	**3**	**1**		**2**
	CO6	**3**	**3**	**2**	**3**	**3**	**2**	**3**	**2**	**3**	**3**	**3**	**1**	**3**	**2**

1=weakly mapped

2= moderately mapped

3=strongly mapped

Unit I	1. Checking the calibration of the thermometer. 2. Purification of organic compounds 3. Determination of the melting points of given organic compounds 4. Effect of impurities on the melting point 5. Determination of boiling point

	6.Chromatography
Local	-
Regional	-
National	-
Global	The syllabus content is relevant at the regional level as it contributes to the development of regional laboratory capabilities and expertise in organic compound purification and analysis.
Employability	The syllabus content is directly relevant to employability, as it focuses on practical skills and techniques that are highly sought after in industries related to chemistry, pharmaceuticals, materials, and research laboratories.
Entrepreneurship	-
Skill Development	The syllabus content specifically focuses on skill development by providing hands-on experience in techniques such as purification, melting point determination, and chromatography, which enhance laboratory skills, analytical thinking, and problem- solving abilities
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Understanding purification techniques can contribute to sustainable practices by ensuring the purity and quality of organic compounds while minimizing waste and contamination.
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP 2020	India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13)Optimal Learning Environments and Support for Students (12.1-12.10)
POE/4th IR	To provide practical sessions with variety of practicals/For Advanced technologies relevant to the chemicals industry student should have hands on exposure of lab processes for e.g. Compound Synthesis, titrations, quantitative and qualitative analysis etc.

Teaching Plan:

Weekly	**Topic/Unit No.**	**Textbook [TB]/**	**Teaching-**
Week 1	Thermometer Calibration	**TB2**	Experime
Week 2	Crystallization with Water	**TB1**	Experime
Week 3	Crystallization with	**TB1**	Experime
Week 4	Crystallization with	**TB1**	Experime
Week 5	Melting Point	**TB2**	Experime

Week 6	Melting Point	**TB2**	Experime
Week 7	Effect of Impurities on	**TB2**	Experime
Week 8	Determination of Boiling	**TB2**	Experime
Week 9	Determination of Boiling	**TB2**	Experime
Week 10	Paper Chromatography	**TB2**	Experime
Week 11	Paper Chromatography	**TB2**	Experime
Week 12	Thin Layer	**TB2**	Experime
Week 13	Recap		Experime

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning	Assess
1	Upon completion of the laboratory experiments, students will be able to demonstrate proficiency in various laboratory techniques and analytical skills used in organic chemistry. They will understand the importance of accurate measurements, proper equipment usage, purification methods, and separation techniques. Students will also develop the ability to interpret experimental results, analyze data, and draw meaningful conclusions. This CLO emphasizes practical skills, critical thinking, and hands-on experience in the field of organic chemistry.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	Experiment

AEC001	New Age Life skills - I	**L**	**T**	**P**	**C**
Version 3.0		**3**	**0**	**0**	**3**
Total Contact Hours	**45**				
Pre-requisites/Exposure	**Basics of Chemistry**				
Co-requisites	--				

COURSE OBJECTIVES:

- To enable learners organize and summarize information clearly and logically
- To develop and build upon their abilities in listening reading and speaking skills.
- To Organize and express ideas in writing in a coherent and pertinent manner in formal setting.
- To Implement the acquired knowledge to imbibe qualities of a Leader
- To recognize the interrelationship between theory and practice apply such knowledge for development.
- To enhance verbal and written communication skills, including clarity, articulation, active listening, and effective presentation skills.

COURSE OUTCOME (COs)

On completion of the course learner should be able to: -
CO1 Develop self confidence in their communication abilities and enabling them to express themselves assertively.
CO 2 Enhance the ability for advanced critical thinking and the ability to formulate logical arguments.
CO 3 Describe different value systems and moral dimensions while taking decisions.
CO 4 Include attributes and personality traits that help learner to interact with others and succeed.

CO 5 Cultivate self-confidence, problem solving and critical thinking abilities

CATALOUGE DESCRIPTION:

New Age Life Skills' course is designed for learner to enhance and develop interpersonal skills that characterize a person's relationships with other professionals. This program will teach skills which will prepare them for a successful career in their industry. The main topics will include verbal communicationalskills, non- verbal communication skills, Active listening skills, written communication skills and presentation skills. They will also develop active listening skills, enabling them to understand others and respond appropriately. Learners will demonstrate proficiency in interpersonal communication, fostering positive relationships and resolving conflicts. Additionally, they will exhibit cross-cultural competence, adapting their communication styles to diverse audiences.

COURSE TOPICS:

Unit 1 **Effective Communication Skills**

Content Summary: Verbal Communication Skills: speaking clearly, using appropriate language and tone, and expressing ideas effectively, Non-Verbal Communication Skills: Body Language Facial Expressions, Posture, Eye Contact, and Gestures, Active Listening Skills: Understanding and Reporting to Other's Messages, Interpersonal Skills: Building Rapport, Empathy, and ResolvingConflicts

Unit 2**Personality development**

Content Summary: - Etiquettes and Manners, Attitude, Self Esteem & Self Reliance, Public Speaking, Work Habits, Presentation Skills/Techniques

Unit 3**Mindset and Resilience**

Content Summary: Knowing and experiencing self, Developing a growth mindset, Strategies for overcoming obstacles and setbacks, Cultivating Resilience and Adaptability

Unit 4 **Enhancing Spoken Skills**

Content Summary: Vocabulary & Pronunciation improvement, Verbal Ability Qs & Ans, Delivery of speech, Motivation, Assertiveness, Confidence building, Story narration, Book review.

Text Book and References

Bayer, Mike (2019), Best Self

Gladwell Malcom, (2021), Talking to strangers

Scot Susan (2004), Fierce conversations

Mode of Evaluation:

Compo nents	Q u	Att end	M i	Presentation /Assignment	E n

We igh	1 0	10	2 0	10	5 0

Program Mapping – PO to CO's

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PEO 1	PEO 2	PEO 3	PEO 4	PEO 5	PEO 6
CO 1								3										3		
CO 2													2							
CO 3																				
CO 4										3										2
CO 5																				

1=lightly mapped 2= moderately mapped 3=strongly mapped

Unit Number 1: Effective Communication Skills

Terms	Content Mapping
Local	Practicing effective communication skills in the local community and workplace.
Regional	Understanding the regional importance of interpersonal skills and conflict resolution.
National	Applying effective communication skills in national contexts and diverse environments.
Global	Understanding the global significance of effective verbal and non-verbal communication in diverse cultural settings.
Employability	Gaining communication skills relevant to employment and career advancement.
Entrepreneurship	Exploring the entrepreneurial importance of effective communication for business success.
Skill development	Developing skills in verbal and non-verbal communication for effective interaction.
Professional ethics	Adhering to professional standards in communication and interpersonal interactions.
Gender	Encouraging equal participation and opportunities in the development of effective communication skills.
Human values	Fostering respect and understanding in communication for building strong relationships.
Environment & sustainability	Promoting effective communication for sustainable and collaborative work environments.
Unit _II	**Content Mapping**
Local	Understanding the local etiquettes, manners, and work habits for personal and professional growth.
Regional	Exploring the regional significance of attitude and self-esteem in personal and career development.
National	Studying the national importance of public speaking and presentation skills for effective communication.
Global	Understanding the global impact of self-reliance and assertiveness in diverse cultural settings.
Employability	Gaining personality development skills relevant to employment and career advancement.

Entrepreneurship	Exploring the entrepreneurial importance of a positive attitude and effective work habits.
Skill development	Developing skills in public speaking, presentation, and self-esteem for personal and professional growth.
Professional ethics	Adhering to professional standards in personal and professional conduct and development.
Gender	Encouraging equal participation and opportunities in personality development and self-improvement.
Human values	Fostering personal growth and self-reliance while respecting others' perspectives.
Environment & sustainability	Promoting a positive work environment through the development of a strong and positive personality.
Unit III	**Content Mapping**
Local	Understanding the local experiences and challenges in developing a growth mindset and resilience.
Regional	Exploring the regional strategies for overcoming obstacles and setbacks in personal nd professional life.
National	Studying the national importance of cultivating resilience and adaptability in diverse situations.
Global	Understanding the global significance of a growth mindset in personal and professional success.
Employability	Gaining mindset and resilience skills relevant to employment and career advancement.
Entrepreneurship	Exploring the entrepreneurial importance of adaptability and resilience for business success.
Skill development	Developing skills in overcoming challenges and developing a positive mindset for personal growth.
Professional ethics	Adhering to professional standards in maintaining resilience and adaptability in diverse environments.
Gender	Encouraging equal participation and opportunities in developing a growth mindset and resilience.
Human values	Fostering personal growth and resilience while upholding ethical values and principles.
Environment & sustainability	Promoting a positive and adaptable work environment through a resilient mindset.
Unit IV	**Content Mapping**
Local	Improving vocabulary and pronunciation skills in the local context for effective communication.
Regional	Exploring the regional significance of verbal ability and effective delivery of speeches for various purposes.
National	Studying the national importance of assertiveness and confidence building in spoken communication.
Global	Understanding the global impact of effective storytelling and book review skills in diverse contexts.
Employability	Gaining spoken skills relevant to employment and effective communication in the workplace.
Entrepreneurship	Exploring the entrepreneurial importance of motivation and confidence in business communication.
Skill development	Developing skills in vocabulary, pronunciation, and effective delivery of speeches for various contexts.
Professional ethics	Adhering to professional standards in spoken communication and effective verbal expression.

Gender	Encouraging equal participation and opportunities in developing effective spoken communication skills.
Human values	Fostering effective communication while upholding values of respect and integrity.
Environment & sustainability	Promoting effective and clear communication for a positive and sustainable work environment.

Teaching Learning method

1	Mon	Verbal Communication Skills	TB/Chapter 1	Lecture, Discussion
	Tue	Non-Verbal Communication Skills	TB/Chapter 2	Presentation, Role Play
	Wed	Active Listening Skills	TB/Chapter 3	Group Activities, Discussion
	Thu	Interpersonal Skills: Building Rapport	TB/Chapter 4	Case Studies, Group Work
	Fri	Practice and Application	Exercises and Scenarios	Role Play, Practice
	Sat	Review and Assessment	Review Questions and Quiz	Quiz and Q&A Session
2	Mon	Communication Skills Workshop	Reference Book / OER	Workshop, Group Discussions
	Tue	Midterm Assessment	Practice Test	Midterm Exam
3	Mon	Etiquettes and Manners	TB/Chapter 1	Lecture, Role Play
	Tue	Attitude and Self-Esteem	TB/Chapter 2	Discussion, Self-Assessment
	Wed	Public Speaking	TB/Chapter 3	Presentation, Practice
	Thu	Work Habits	TB/Chapter 4	Group Activities, Discussion
	Fri	Presentation Skills/Techniques	TB/Chapter 5	Role Play, Practice
	Sat	Review and Assessment	Review Questions and Quiz	Quiz and Q&A Session
4-6	(Repeat)	Personality Development (Weeks 4-6)		(Repeat Week 3 Schedule)
7-9	(Repeat)	Mindset and Resilience (Weeks 7-9)		(Repeat Week 3 Schedule)
10-12	(Repeat)	Enhancing Spoken Skills (Weeks 10-12)		(Repeat Week 3 Schedule)
13	Mon	Course Review and Q&A Session	Review Materials	Review, Q&A Session

14	Tue	Final Assessment and Course Conclusion	Final Exam	Final Exam and Course Wrap-up

Facilitating the Achievement of Course Learning Outcomes

No.	Learning Outcomes	Teaching-Learning Activities	Assessment Task Methods
1	- Effective verbal communication skills (LO1) - Proficient non-verbal communication skills (LO2) - Active listening skills and reporting (LO3) - Interpersonal skills, rapport, and conflict resolution (LO4)	- Lectures, role-playing exercises, language practice - Classroom discussions, demonstrations, group activities - Active listening exercises, mock scenarios - Case studies, group activities, peer feedback	- Oral presentations, role-play assessments - Observation, class participation - Listening assessments, reports - Group projects, peer evaluations, essays
2	- Etiquette and manners (LO1) - Positive attitude and self-esteem (LO2) - Public speaking and presentation skills (LO3) - Effective work habits (LO4) - Presentation skills and techniques (LO5)	- Workshops, role-plays, real-life scenarios - Discussions, self-reflection, self-assessment - Workshops, practice sessions, presentations - Discussions, role-play exercises, goal-setting - Workshops, group projects, individual presentations	- Etiquette assessment, observation, role-plays - Self-assessment, reflection essays - Public speaking evaluations, presentation assessments - Work habit assessments, role-play assessments - Presentation assessments, peer evaluations
3	- Self-understanding and personal growth (LO1) - Growth mindset and overcoming obstacles (LO2) - Resilience and adaptability (LO3)	- Self-awareness activities, reflective journaling - Workshops, group problem-solving activities - Resilience-building exercises, role-playing scenarios	- Personal growth essays, self-assessments, journals - Growth mindset self-assessment, problem-solving assessments - Resilience assessments, role-play assessments
4	- Vocabulary and pronunciation improvement (LO1) - Verbal ability questions and answers (LO2) - Delivery of speech and motivation (LO3) - Assertiveness and confidence building (LO4) - Story narration and book review (LO5)	- Exercises, group discussions, pronunciation drills - Question-answer sessions, group discussions, practice - Speech delivery practice, motivational activities - Role-play scenarios, confidence-building exercises - Storytelling sessions, book review assignments	- Vocabulary quizzes, pronunciation assessments, group discussions - Verbal ability assessments, group discussions, drills - Speech assessments, motivational assessments - Role-play assessments, confidence-building assessments - Storytelling assessments, book review assessments

SEC007	Groundwater Modelling	L	T	P	C
Version 3.0		2	0	0	2
Total Contact Hours	30				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

COURSE OBJECTIVES

The course will enable the student-teacher to:

- To provide an insight to students into the field of groundwater hydrology.
- To impart knowledge of important issues to hydrological modelling including both surface water modelling and groundwater modelling
- To provide the basic knowledge needed to understand and to be able model fluids in motion in porous media (groundwater)

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Assess of groundwater flow and regional groundwater flow modelling.
CO2: Identify of groundwater source by groundwater prospecting.
CO3: Design water wells.
CO4: Manage groundwater resources.
CO5: Plan and design artificial recharge systems

CATALOG DESCRIPTION

Groundwater modelling is a fundamental aspect of hydrogeology, enabling the accurate representation and prediction of the movement and distribution of groundwater within the subsurface. This comprehensive course introduces students to the principles, techniques, and applications of groundwater modelling, equipping them with the necessary knowledge and skills to address real-world water resource management and environmental challenges. The syllabus covers essential theoretical concepts, hands-on practical exercises, and case studies to enhance understanding and proficiency in groundwater modelling.

COURSE CONTENT

Unit I: 7lecture

Introduction to Groundwater and its movement:

Ground water availability, Groundwater in the hydrologic system, Hydrologic budget, Vertical distribution of subsurface strata, Types of aquifers, Aquifer characteristics.

Unit II: 8Lecture

Groundwater Movement:

Darcy's law, Hydraulic conductivity and intrinsic permeability, Transmissivity, Homogeneity and isotropy, Stream function, Flownet.

Unit III: **7Lecture**

Groundwater Modelling:
Groundwater modelling, regional groundwater flow modelling, Types of models-physical scale model, Analog models-their principles, characteristics applications and limitations. R-C Analog model-Advantages and limitations. Mathematical models-Analytical and Numerical approaches, Stochastic models.

Unit IV: **8Lecture**
GroundwaterProspecting and management:
Geologic method, Remote sensing, Geophysical exploration, Electric resistivity method, Seismic method, Gravity and magnetic methods

Groundwater Management: Concept of basin management, Conjunctive use of surface water and groundwater, Groundwater management techniques

Text Books:
1. Groundwater Hydrology: Engineering, Planning and Management, Karamouz, M., Ahmadi, A., and Akhbari, M., CRC Press, Taylor et Francis Group, 2020 2.
2. Groundwater Hydrology, Todd, D. K., and Mays, L. W., John Wiley & Sons, Singapore, 2018 3. Numerical Groundwater Hydrology, Rastogi, A.K., Penram International Publishing Pvt. Ltd., 2012

Reference Books:
1. Hydrogeology, Davis, S. N., and De Weist, R. J. M., John Wiley & Sons, New York, 2013
2. Groundwater Hydrology, Chahar, B. R., McGraw Hill Education (India) Private Limited, New Delhi, 2015

Open Educational Resources (OER)
• GW&P: Lesson 1 Introduction to Groundwater (iasri.res.in)
• Hydraulic Conductivity vs. Intrinsic Permeability (ebrary.net)
• (12) Velocity Potential and Stream function | Fluid Mechanics | stream function | velocity potential - YouTube
• (12) Engineering Hydrology | Groundwater Modelling Techniques | AKTU Digital Education - YouTube
• Introduction to Groundwater Modelling | PPT (slideshare.net)
• JETIR1807867.pdf

• Tools for groundwater prospecting and geophysical prospecting for water in Ocotal, Nicaragua: a minor field study (diva-portal.org)

- **Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**
  Examination Scheme:

Components	Quiz/Assignm	Mid Term	Attendance	End Term
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course Code and Title	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SEC007 Groundwater Modelling	CO1			3	3	3						3	3		
	CO2	3		3				2			2	3	3	3	
	CO3		3			3								3	
	CO4		3	3	3	3	2	2			3		3		
	CO5		3	3	3	3	3			3		3	3	3	

Unit I	Introduction to Groundwater and its movement
Local	-
Regional	-
National	-
Global	Recognizing global groundwater issues and their impact on water security.
Employability	-
Entrepreneurship	-)
Skill Development	Developing expertise in hydrogeological techniques, aquifer characterization, and groundwater modeling.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Promoting responsible groundwater management for environmental protection and sustainability.
Unit II	**Groundwater Movement**
Local	-
Regional	-
National	Comprehending national groundwater flow dynamics and their

	implications
Global	-
Employability	-
Entrepreneurship	Identifying entrepreneurial opportunities in groundwater modeling and aquifer characterization services.
Skill Development	Developing expertise in Darcy's law, hydraulic conductivity, and groundwater flow modeling.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Promoting responsible groundwater modeling for environmental protection and sustainability.
Unit III	Groundwater Modelling
Local	-
Regional	-
National	-
Global	Recognizing global approaches to groundwater modeling and hydrogeological research.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in various groundwater modeling approaches, including mathematical and stochastic models.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Promoting responsible groundwater modeling for sustainable resource management.
Unit IV	Groundwater Prospecting and Management
Local	-
Regional	-
National	-
Global	Recognizing global practices in groundwater resource assessment and management.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in geologic methods, remote sensing, and geophysical exploration for groundwater prospecting.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Promoting responsible groundwater prospecting and management for environmental protection and sustainability.

SDG	Skill for Decent Work; Sustainable Development and Global Citizenship
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Global Education Knowledge, imagination/creativity, assumption of responsibility and for making decisions, planning, coordinating and organising ability

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page	Teaching -
Week 1	**Unit 1:** Ground water availability, Groundwater in the	**TB-1/ RB-1/ OER-1**	Group Discussio
Week 2	**Unit 1:** Hydrologic budget, Vertical	**TB-1/ RB-1/ OER-1**	Group Discussio
Week 3	**Unit 1:** Types of aquifers, Aquifer	**TB-1/ RB-1/ OER-1**	Group Discussio
Week 4	**Unit 2:** Darcy's law, Hydraulic conductivity	**TB-1/ RB-1/OER-2**	Group Discussio
Week 5	**Unit 2:** Intrinsic permeability,	**TB-1/ RB-1/OER-2/3**	Group Discussio
Week 6	**Unit 3:** Groundwater modelling, regional groundwater flow	**TB-1/ RB-1/OER-4**	Group Discussio
Week 7	**Unit 3:** Types of models-physical scale	**TB-1/ RB-1/OER-4**	Group Discussio
Week 8	**Unit 3:** Analog models-their principles,	**TB-1/ RB-1/OER-5**	Group Discussio
Week 9	**Unit 3:** R-C Analog model-Advantages and	**TB-1/ RB-1/OER-5**	Group Discussio
Week 10	**Unit 4:** Geologic method, Remote sensing,	**TB-1/ RB-1/OER-6**	Group Discussio

Week 11	**Unit 4:** Geophysical exploration, Gravity	**TB-1/ RB-1/OER-6**	Group Discussio
Week 12	**Unit 4:** Electric resistivity method,	**TB-1/ RB-1/OER-7**	Group Discussio
Week 13	**Unit 4:** Conjunctive use of surface water and groundwater,	**TB-1/ RB-1/OER-7**	Group Discussio
Week 14	**Revision**	**TB-1/RB-1**	Group Discussio

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning	Assessment
1	Grasp the fundamental concepts of groundwater systems, including aquifer properties, flow mechanisms, and contaminant transport processes.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	Presentations and class discussions. • Assignments and class tests. • Student presentations. •Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Describe the various components of groundwater systems and their interactions with surface water.		
3	Gain proficiency in both analytical and numerical groundwater modelling techniques. They will learn how to set up, solve, and interpret groundwater flow and contaminant transport models using appropriate software.		
4	knowledge of modelling groundwater-surface water interactions, which are crucial in understanding the interconnectivity between surface water bodies and groundwater systems.		

VAC151	**Environmental Studies+Disaaster Management**	L	T	P	C

Version 2.0		2	0	0	2
Total Contact Hours	30				
Pre-requisites/Exposure	Basics of Environment				
Co-requisites	--				

Course Objective:

1. Develop a deep awareness of environmental issues and the need for public engagement.
2. Understand land and water resource challenges and their impacts.
3. Learn to identify, control, and mitigate various forms of pollution.
4. Explore sustainable development concepts and environmental laws.
5. Gain expertise in disaster preparedness, response, and technology applications.

Course Outcome:

CO1: Knowledge: Students will recall environmental concepts and legislation.
CO2: They will understand the causes and effects of environmental issues.
CO3: Students will apply their knowledge to solve real-world problems.
CO4: They can analyze relationships between environmental factors.
CO5: Students will create disaster plans and sustainable strategies.
CO6: They will evaluate disaster frameworks and policy impacts.

Course Content

UNIT I **8 Lectures**

Environment and Natural Resources:
Multidisciplinary nature of environmental sciences; Scope and importance; Need for public awareness.
Land resources; land use change; Land degradation, soil erosion and desertification.
Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations.
Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state).
Energy resources: Renewable and non- renewable energy sources, use of alternate energy sources, growing energy needs, case studies. Carbon Footprints.

UNIT II **7 Lectures**

Environmental Pollution and Environmental Policies:
Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution Nuclear hazards and human health risks; Solid waste management: Control measures of urban and industrial waste; Pollution case studies.

Sustainability and sustainable development; Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture; Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; wildlife Protection Act; Forest Conservation Act; Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context. Fundamentals and Application of ESG (Environment Social Governance).

UNIT III **8 Lectures**

Introduction to Disasters:

Concept and definitions- Disaster, Hazard, vulnerability, resilience, risks.

Different Types of Disaster: Causes, effects and practical examples for all disasters. Natural Disaster: such as Flood, Cyclone, Earthquakes, Landslides etc. Man-made Disaster: such as Fire, Industrial Pollution, Nuclear Disaster, Biological Disasters, Accidents (Air, Sea, Rail & Road), Structural failures (Building and Bridge), War & Terrorism etc.

UNIT- IV **7 Lectures**

Disaster Preparedness Plan, Prediction, Early Warnings and Safety Measures of Disaster, Role of Government, International and NGO Bodies in Disaster Preparedness. Reconstruction and Rehabilitation, Post Disaster effects and Remedial MeasuresDisaster Management Act, 2005: Disaster management framework in India before and after Disaster Management Act, 2005, Applications of AI and ML in Disaster Management and risk predictions.

Text Books

1. Content building programme (CBP) book on Disaster Management, Forum AS.
2. Kaushik and Kaushik, Environmental Studies, New Age International Publishers (P) Ltd. New Delhi.

Reference Books/Materials

1. A.K. De, Environmental Chemistry, New Age International Publishers (P) Ltd. New Delhi.
2. S.E. Manahan, Environmental Chemistry, CRC Press.
3. S.S Dara and D.D. Mishra, Environmental Chemistry and Pollution Control, S.Chand & Company Ltd, New Delhi.

Open Educational Resources (OER)

- OpenStax
- Khan Academy
- MIT OpenCourseWare
- Coursera and edX
- YouTube
- Wikibooks
- OER Commons
- NOAA Education
- UNEP Education

- TED Talks

Programme and Course Mapping

Course Code and Title	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
VAC151 Environmental Studies+Disaaster Management	CO1	3	2	1	1	2	1	1	1	1	1	1	1	1	1
	CO2	2	3	1	1	2	1	1	1	1	1	1	1	1	1
	CO3	1	1	3	1	2	2	2	1	1	1	1	1	1	1
	CO4	1	1	1	3	2	1	1	1	1	1	1	1	1	1
	CO5	1	1	1	1	3	2	1	1	1	1	1	1	1	1
	CO6	1	1	1	1	1	3	2	1	1	1	1	1	1	1

Unit I	Environment and Natural Resources:
Local	-
Regional	-
National	Contributing to national environmental awareness and conservation efforts.
Global	-
Employability	Participating in global environmental discussions and actions.
Entrepreneurship	Student centric methods, such as experiential learning, participative learning and problem-solving methodologies (2.3.1)
Skill Development	Developing problem-solving and analytical skills.
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit II	Environmental Pollution and Environmental Policies
Local	-
Regional	-
National	Contributing to national forest conservation and biodiversity protection.
Global	Engaging in global discussions on deforestation and its impacts.
Employability	-

Entrepreneurship	Student centric methods, such as experiential learning, participative learningand problem-solving methodologies (2.3.1)
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit III	Introduction to Disasters
Local	-
Regional	-
National	Contributing to national water resource management and conflict resolution.
Global	Chemical composition of atmosphere
Employability	-
Entrepreneurship	-
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit IV	
Local	-
Regional	-
National	-
Global	Engaging in global discussions on energy sustainability and alternatives.
Employability	Meeting the demands of carbon-conscious industries.
Entrepreneurship	-
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.

SDG	Aligning with Sustainable Development Goals related to climate action.
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Global Education Knowledge, imagination/creativity, assumption of responsibility and for making decisions, planning, coordinating and organising ability

Week	Topics/Unit Number	Textbook/Reference Book-	Teaching-
1-2	Unit I: Environment and Natural		
Week 1	Introduction to Environmental	Recommended Textbook: [Title	Lecture,
Week 2	Land Resources and Land Use	Recommended Textbook: [Title	Lecture,
3-4	Water Resources		
Week 3	Water Use, Over-exploitation, and	Recommended Textbook: [Title	Lecture, Case
Week 4	Water Conflicts and Case Studies	Recommended Textbook: [Title	Lecture, Group
5-6	Energy Resources and		
Week 5	Renewable and Non-renewable	Recommended Textbook: [Title	Lecture, Visual
Week 6	Types, Causes, Effects, and	Recommended Textbook: [Title	Lecture, Case
7-8	Unit II: Sustainability and Climate		
Week 7	Sustainability and Sustainable	Recommended Textbook: [Title	Lecture,

Week 8	Climate Change and Its Impact	Recommended Textbook: [Title	Lecture, Case
9-10	Unit III: Introduction to Disasters		
Week 9	Introduction to Disasters, Types,	Recommended Textbook: [Title	Lecture, Case
Week 10	Disaster Preparedness and Early	Recommended Textbook: [Title	Lecture,
11-12	Unit IV: Disaster Management and		
Week 11	Role of Government, International	Recommended Textbook: [Title	Lecture, Guest
Week 12	Post-Disaster Effects and Remedial	Recommended Textbook: [Title	Lecture, Group

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning	Assessment Task
1	Multidisciplinary nature of environmental sciences. - Importance of environmental sciences.	Lecture on multidisciplinary nature. - Group discussions on importance. - Case studies on deforestation. - Guest lectures on impact assessments. - Case studies on water conflicts. - Analysis of energy sources. - Experiments and guest lectures. - Case studies on pollution.	Quiz on key concepts. - Group presentation on awareness. - Case study reports. - Group discussions and debates. - Problem-solving exercises. - Group presentations. Pollution assessments. - Reports and written exams.
2	- Causes and impacts of deforestation. - Effects of mining and dam construction.		
3	- Water resource issues and conflicts. - Renewable and non-renewable energy sources.		
4	Identifying types of environmental pollution. - Impact of pollution on health and the environment.		

SEMESTER II

SCCH102	**Physical Chemistry-I**	L	T	P	C

Version 3.0		3	1	0	4
Total contact hours	60				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

Course Objectives

1. To be able to differentiate between the three states of matter on the basis of their properties.
2. To learn about various gas laws and equations (ideal and Van Der Waals)
3. To understand various aspects related to ionic equilibrium.
4. To develop an understanding of the arrangement of atoms/ions in crystalline solids.

Course Outcomes

On completion of this course, the students will be able to

CO1: Describe deviations from ideal gas behavior, calculate compressibility factors, and apply the van der Waals equation to explain real gas behavior.
CO2: Derive the kinetic gas equation, calculate collision frequency and mean free path, analyze molecular velocities, and explain the molecular basis of heat capacities.
CO3: Evaluate vapor pressure, surface tension, and viscosity of liquids, and describe how these properties depend on temperature and pressure. Understand the structure of water and the effects of solutes on surface tension.
CO4: Identify strong, moderate, and weak electrolytes, calculate ionization constants and pH, analyze buffer solutions and their applications, and apply the Brönsted-Lowry and Lewis acid-base concepts. Additionally, understand qualitative aspects of acid-base titration curves and the theory of indicators.

Catalogue Description

This course imparts the basic concepts of states of matter and ionic equilibrium. It enables the students to learn about the various properties which are unique to solids, liquids and gases. The course will help to explain several gas laws, and equation with the help of kinetic theory of gases. The course introduces the basic concepts about ionic equilibrium, namely, ionisation, hydrolysis, titrations buffer solutions, acid-base titrations, etc. stacks, queues, lists, trees and graphs. It also discusses about the structure and arrangement at the atomic level in the liquid state and the solid state.

Course Content

Unit I: **15Lectures**

Gaseous state

Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, and its variation with pressure for different gases. Causes of deviation from ideal behavior., relation between mean free path and coefficient of viscosity.Deviations from ideal gas behavior, compressibility factor *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behavior ,van der Waals equation of state, its derivation and application in explaining real gas behaviour; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states.

Unit II: **15Lectures**

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

Liquid state

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water.

Unit III: **15Lectures**

Ionic equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-protic acids.Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts.Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product. Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations.Multistage equilibria in polyelectrolytes.

Unit IV: **15Lectures**

Solid State

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Millerindices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitativeidea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-raydiffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method.Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Various types of defects in crystals,Glasses and liquid crystals.

Text Books

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).

Reference Books/Materials

1. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
2. G. M. Barrow, Tata McGraw Hill (Fifth Edition) (2007)

Open Educational Resources (OER)

https://www.oercommons.org/
https://www.merlot.org/merlot/index.htm
https://ocw.mit.edu/index.htm
https://www.khanacademy.org/
https://openstax.org/
https://www.coursera.org/courses?query=free
https://epathshala.nic.in/
http://chemcollective.org/
http://nsdl.niscair.res.in/
https://www.youtube.com/watch?v=3m-TNF0qTrE

Modes of Evaluation: Quiz/Assignment/presentation/extempore/Written Examination

Components	Quiz/Assignment/ Presentation	Attendance	Mid Term Exam	End Term Exam
Weightage (%)	**20**	10	20	50

Programme and Course Mapping

Course Code and Title	Course Outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SCCH102PHYSICAL CHEMISTRY-I	**CO1**	**3**	**2**	**1**	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**3**	**1**	**1**	**1**
	CO2	**1**	**3**	**2**	**3**	**1**	**3**	**1**	**2**	**1**	**1**	**3**	**3**	**3**	**2**
	CO3	**2**	**3**	**3**	**2**	**1**	**2**	**1**	**3**	**2**	**1**	**2**	**3**	**3**	**3**

	CO4	**3**	**1**	**1**	**3**	**1**	**1**	**2**	**1**	**2**	**1**	**2**	**2**	**2**	**3**

Unit I	Gaseous state
Local	-
Regional	-
National	-
Global	The course will help to explain several gas laws, and equation with the help of kinetic theory of gases
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	Gaseous state and Liquid State
Local	-
Regional	-
National	-
Global	Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Ionic equilibria
Local	-
Regional	-
National	-
Global	Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of

	water.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Solid State
Local	-
Regional	-
National	-
Global	Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a Various types of defects
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13)
POE/4th IR	Technical Skills that match Industry Needs

Teaching Plan:

Week	Topics/Unit Number	Textbook/Reference Book-Chapter/ Open Education Resources	Teaching-Learning Method
1	Gaseous state (Unit I)	Chapter 1: Behavior of Real Gases and OER Commons	Lecture, Presentation, Discussion
2	Gaseous state (Unit I)	Chapter 1: van der Waals Equation and Khan Academy	Lecture, Problem

			Solving, Q&A
3	Kinetic molecular model (Unit II)	Chapter 2: Kinetic Gas Equation and MIT OCW	Lecture, Experiment, Group Work
4	Kinetic molecular model (Unit II)	Chapter 2: Maxwell Distribution and Chem Collective	Lecture, Simulation, Q&A
5	Liquid state (Unit II)	Chapter 3: Structure and Properties and YouTube Channels	Lecture, Demonstration, Q&A
6	Liquid state (Unit II)	Chapter 3: Vapour Pressure and NCERT E-Pathshala	Lecture, Experiment, Group Discussion
7	Ionic equilibria (Unit III)	Chapter 4: Strong, Moderate, Weak Electrolytes and OER Commons	Lecture, Case Study, Q&A
8	Ionic equilibria (Unit III)	Chapter 4: Ionization of Weak Acids/Bases and Merlot	Lecture, Problem Solving, Q&A
9	Solid state (Unit IV)	Chapter 5: Nature of Solid State and MIT OCW	Lecture, Experiment, Group Work
10	Solid state (Unit IV)	Chapter 5: X-ray Diffraction and Khan Academy	Lecture, Simulation, Q&A
11	Review & Revision	Review all topics covered so far	Review, Discussion, Q&A
12	Test and Assessment	Assess understanding and progress	Test, Evaluation, Feedback
13	Application of Chemistry	Chapter 6: Applications of Chemistry and ChemCollective	Lecture, Case Studies, Group Work
14	Application of Chemistry	Chapter 6: Case Studies and YouTube Channels	Lecture, Discussion, Q&A

Facilitating the Achievement of Course Learning Outcomes

Unit Number	**Course Learning Outcomes (CLOs)**	**Teaching-Learning Activities (TLAs)**	**Assessment Task Methods**

Unit I	Analyze and explain deviations from ideal gas behavior.	Lectures on real gases and deviations from ideal behavior.Practical demonstrations of kinetic gas equation derivations and molecular velocities.Classroom discussions and problem-solving activities on ionic equilibria.,Lectures on crystal systems, Bravais lattices, and symmetry elements.	Written examination with questions related to gas behavior.,Lab reports assessing accuracy of derived kinetic gas equation, Quizzes and tests assessing knowledge of ionization constants.Written or oral exams evaluating understanding of crystal systems.
Unit II	Derive and apply the kinetic gas equation.		
Unit III	Evaluate the ionization constants and pH scale.		
Unit IV	Describe the nature of the solid state and symmetry elements.		

SCCH152	**Physical Chemistry-I Practicals**	L	T	P	C
Version 3.0		0	0	4	2
Total contact hours	30				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

Course Objectives

1. To be able to use simple glass instruments like viscometer and stalagmometer.
2. To calculate the values of surface tension and viscosity from the relevant experimental readings.
3. To use a pH-meter and measure the pH value of any given solution.
4. To understand the theory of pH-metric titrations.

Course Outcomes

On completion of this course, the students will be able to

CO1: Apply surface tension measurement techniques

CO2: Utilize Ostwald's viscometer to determine viscosity for different aqueous solutions

CO3: Analyze pH changes upon the addition of HCl/NaOH to solutions
CO4: Perform pH metric titrations for strong acid vs. strong base and weak acid vs. strong base reactions.

Catalog Description

This course imparts the basic concepts of physical chemistry experiments. It enables the students to learn the usage of simple instruments like viscometer and stalagmometer. The course will explain the working theory behind a pH-meter, and how to carry out measurements and pH-metric titrations.The course introduces the basic concepts about buffer solutions and the students will observe the resistance in pH change of buffer solutions.

Course Content

1. Surface tension measurements.

a. Determine the surface tension by (i) drop number (ii) drop weight method.

b. Study the variation of surface tension of detergent solutions with concentration. .

2. **Viscosity measurements using Ostwald's viscometer**.

(a) Study the effect of the addition of solutes such as (i) polymer (ii) ethanol (iii) sodium chloride on the viscosity of water at room temperature.

(b) Study the effect of variation of viscosity of an aqueous solution with the concentration of solute.

3. pH metry

a. Effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.

b. Preparation of buffer solutions of different pH

i. Sodium acetate-acetic acid

j. Ammonium chloride-ammonium hydroxide

c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

d. Determination of dissociation constant of a weak acid.

Recommended text books/references:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi(2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York(2003).
4. Athawale V. D. amd Mathur P. Experimental Physical Chemistry,, New Age Intenational (2001)

Open Educational Resources

https://www.khanacademy.org/
https://www.coursera.org/
https://www.open.edu/openlearn/
https://ocw.mit.edu/index.htm
https://openstax.org/

http://chemcollective.org/

https://libretexts.org/

https://nptel.ac.in/

http://www.chemguide.co.uk/

https://www.saylor.org/

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	**Conduct of Experiment**	**Lab Record/Quizzes / Viva-Voce**	**Attendance**	**End Term PracticalExamination**
Weightage (%)	**20**	**20**	**10**	**50**

Programme and Course Mapping

Course code and Title	**Course Outcomes (COs)**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
SCCH152 Physical Chemistry-I Practicals	**CO1:**	3	2	1	3	1	2	1	3	3	2	3	3	2	2
	CO2:	3	3	1	3	1	2	1	3	3	2	3	2	3	1
	CO3:	3	3	1	3	1	2	1	3	3	2	3	2	3	3
	CO4:	2	2	2	3	1	2	2	3	2	3	3	3	3	2

Unit	1. Surface tension measurements. 2. Viscosity measurements using Ostwald's viscometer 3.pH metry
Local	-
Regional	-
National	-
Global	working theory behind a pH-meter, and how to carry out measurements and pH-

	metric titrations
Employability	Use of simple instruments like viscometer and stalagmometer, working theory behind a pH-meter, and how to carry out measurements and pH-metric titrations. Basic concepts about buffer solutions.
Entrepreneurship	-
Skill Development	Use of simple instruments like viscometer and stalagmometer, working theory behind a pH-meter, and how to carry out measurements and pH-metric titrations. Basic concepts about buffer solutions.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13)Optimal Learning Environments and Support for Students (12.1-12.10)
POE/4th IR	To provide practical sessions / hands on exposure of lab processes

Teaching Plan:

Weekly teaching plan	**Topic /Unit No.**	**Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]**	**Teaching-Learning Method**
Week 1	Surface tension: Drop number method	TB: Ch. 5, Pg. 78-85	OER: Surface Tension Basics
Week 2	Surface tension: Drop weight method	TB: Ch. U5, Pg. 86-92	OER: Drop Weight Method
Week 3	Surface tension of detergent solutions	TB: Ch. 6, Pg. 102-110	RB: Chemistry Handbook
Week 4	Viscosity measurements: Ostwald's viscometer	TB: Ch. 7, Pg. 120-128	OER: Viscosity Basics
Week 5	Viscosity of aqueous solutions (polymers, ethanol)	TB: Ch. 7, Pg. 129-135	RB: Physics of Fluids
Week 6	Viscosity of aqueous solutions (sugar)	TB: Ch. 7, Pg. 136-141	RB: Chemical Engineering
Week 7	Viscosity of sucrose	TB: Ch. 7, Pg. 142-150	RB: Physical

	solution		Chemistry
Week 8	pH meter: Effect of HCl/NaOH on solutions	TB: Ch. 10, Pg. 190-198	OER: pH and Acids/Bases
Week 9	Preparation of sodium acetate-acetic acid buffer	TB: Ch. 10, Pg. 199-205	RB: Analytical Chemistry
Week 10	Preparation of ammonium chloride-ammonium hydroxide	TB: Ch. 10, Pg. 206-210	RB: Biochemistry
Week 11	pH metric titration: Strong acid vs. strong base	TB: Ch. 11, Pg. 220-227	RB: Chemical Analysis
Week 12	pH metric titration: Weak acid vs. strong base	TB: Ch. 11, Pg. 228-235	RB: Titration Techniques
Week 13	Determination of weak acid dissociation constant	TB: Ch. 11, Pg. 236-245	RB: Acid-Base Equilibria
Week 14	Recap and review of topics covered		Revision

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activities	Assessment Task Methods
1	Understand surface tension measurement methods	Lectures on surface tension concepts and drop number/weight methods	Quiz on surface tension theories and methods
2	Apply drop number and drop weight methods	Laboratory demonstration and practice of drop number/weight measurements	Lab report on surface tension measurements
3	Analyze surface tension variations with detergent conc.	Group discussion and data analysis of detergent solution experiments	Group presentation on detergent solution findings
4	Learn Ostwald's viscometer usage and viscosity measurement	Lectures on viscosity principles and Ostwald's viscometer	Quiz on viscosity theories and viscometer use

SCCH104	**Organic Chemistry-II**	L	T	P	C
Version 3.0		3	1	0	4
Total Contact Hours	60				
Pre-requisites/Exposure	Basics of reaction mechanism				
Co-requisites	--				

Course Objectives

1. Understanding of the organic functional groups, which include halogenated hydrocarbons and oxygen containing functional groups and their reactivity patterns.
2. The detailed reactions mechanistic pathways for each functional group will be discussed to unravel the spectrum of organic chemistry and the extent of organic transformations.

Course Outcomes

On completion of this course, the students will be able to

CO1. Understand preparation, properties and reactions of haloalkanes and haloarenes

CO2. Understand preparation, properties and reactions of alcohols and phenols

CO3. Learn the chemistry of named reactions related to carbonyl compounds.

CO4. Understand preparation, properties and reactions of Carboxylic acids.

CO5. Apply the knowledge of synthetic chemistry learnt in this course to do functional group transformations

CO6. Propose possible mechanisms for any relevant reaction.

Catalog Description

This course contains chemistry of halogenated compounds, alcohols and phenols. Course also contributes various name reactions of carbonyl compounds including details of carboxylic acids.

Course Content

UNIT I

Chemistry of Halogenated Hydrocarbons **15 Lectures**

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN^1, SN^2 and S_NI mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism.Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.Organometallic compounds of Mg and Li and their use in synthesis.

UNIT II

Alcohols, Phenols, Ethers and Epoxides **15 Lectures**

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction;Preparationandpropertiesofglycols:Oxidationbyperiodicacidandleadtetraacetate, Pinacol-Pinacolonerearrangement.
Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.
Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

UNIT III
Carbonyl Compounds **15 Lectures**

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff- Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC);
Addition reactions of unsaturated carbonyl compounds: Michael addition.Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

UNIT IV

Carboxylic Acids and their Derivatives **15 Lectures**
Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric,maleicandfumaricacids;Preparationandreactionsofacidchlorides,anhydrides,estersand amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtiusrearrangement.

Sulphur containing compounds

Preparation and reactions of thiols, thioethers and sulphonic acids.

Recommended Books/references:
1 Bahl and Bahl, Advanced Organic Chemistry, S. Chand Publication House.
2 Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry*, John Wiley & Sons, Inc(2009).

3 McMurry, J.E. *Fundamentals of Organic Chemistry*, Seventh edition Cengage Learning, 2013.

4 P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, New Delhi.

4 Morrison R. T. and Boyd R. N. Organic Chemistry, Sixth Edition Prentice Hall India,2003.

Open Educational Resources (OER)

- Alkyl Halides and Aryl Halides Class 12 | Lecture 1 | JEE Main | JEE Advanced |Harsh Sir| Vedantu - Bing video
- Alcohol Phenol and Ethers in 3 Hours for Class 12 Boards | Complete NCERT + Notes - Bing video
- Carbonyl Compounds I Class12 | JEE | NEET (L1) | MOP of Carbonyl Compounds - Bing video
- Carboxylic Acids Class 12 Chemistry | NCERT Chapter 12 CBSE One Shot CBSE JEE NEET - Bing video

Assessment & Evaluation

Components	Quiz/Assignment / Presentation	Attendance	Mid Term Exam	End Term Exam
Weightage (%)	**20**	10	20	50

Course Code and Title	Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2	PSO 3	PSO 4
SCCH104 Organic Chemistry-II	**CO1**	3	3	2	3		2		2		3	3	1		2
	CO2	3	3	2	3		2		2		3	3	1		2
	CO3	3	3	2	3		2		2		3	3	1		2
	CO4	3	3	2			2	2		2		3	2	3	2
	CO5	3	3	2	3		2	3	2		3	3	1		2
	CO6	3	3	2	3	3	2	3	2	3	3	3	1	3	2

1=weakly mapped

2= moderately mapped

3=strongly mapped

Unit I	Chemistry of Halogenated Hydrocarbons
Local	-
Regional	-
National	-
Global	Understanding the basics of organic chemistry has global relevance as it forms the foundation for worldwide collaborations in research, development, and the manufacturing of organic compounds.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	Alcohols, Phenols, Ethers and Epoxides
Local	-
Regional	-
National	-
Global	Understanding the basics of organic chemistry has global relevance as it forms the foundation for worldwide collaborations in research, development, and the manufacturing of organic compounds.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Carbonyl Compounds
Local	-
Regional	-
National	-
Global	Understanding the basics of organic chemistry has global relevance as it

	forms the foundation for worldwide collaborations in research, development, and the manufacturing of organic compounds.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Carboxylic Acids and their Derivatives
Local	-
Regional	-
National	-
Global	Understanding the basics of organic chemistry has global relevance as it forms the foundation for worldwide collaborations in research, development, and the manufacturing of organic compounds.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Technical Skills that match Industry Needs/Skill Embedded Courses. DevelopmentEntrepreneurship (Chemical analyst, Chemical manufacturing industry: Pharmaceutical Industry etc.)

Teaching Plan:

Weekly Teaching	**Topic/Unit No.**	**Textbook [TB]/ Reference Book [RB]-**	**Teaching-Learning Method**
Week 1	Chemistry of Halogenated	**TB1-11**	Lecture, Discussion
Week 2	Chemistry of Halogenated	**TB1-11**	Lecture

Week 3	Chemistry of Halogenated	**TB1-2/TB1-31**	Lecture
Week 4	Chemistry of Halogenated	**TB1-2/TB1-31**	Lecture, Problem solving
Week 5	Alcohols, Phenols, Ethers and Epoxides	**TB1-13**	Lecture, Discussion
Week 6	Alcohols, Phenols, Ethers and Epoxides	**TB1-13**	Lecture
Week 7	Alcohols, Phenols, Ethers and Epoxides	**TB1-15**	Lecture
Week 8	Alcohols, Phenols, Ethers and Epoxides	**TB1-35**	Lecture, Problem
Week 9	Carbonyl Compounds	**TB1-17**	Lecture, Discussion
Week 10	Carbonyl Compounds	**TB1-17**	Lecture
Week 11	Carbonyl Compounds	**TB1-17**	Lecture
Week 12	Carbonyl Compounds	**TB1-36**	Lecture, Problem solving
Week 13	Carboxylic Acids and their Derivatives	**TB1-18**	Lecture, Discussion
Week 14	Carboxylic Acids and their Derivatives	**TB1-18, 19**	Lecture
Week 15	Carboxylic Acids and their Derivatives	**TB1-19, 20**	Lecture
Week 16	Carboxylic Acids and their Derivatives	**TB1-20**	Lecture, Problem solving

Facilitating the Achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching Learning Activity**	**Assessment Task Methods**
1 **2** **3** **4**	In this course, students will delve into the intricacies of halogenated compounds, alcohols, phenols, and carbonyl compounds. They will grasp the nomenclature, structures, and properties of halogenated compounds, while exploring their synthesis methods and potential environmental	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignm	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.

	impacts. The course will also cover the properties and reactivity of alcohols and phenols, along with their preparation techniques and practical applications. Students will gain insights into important name reactions involving carbonyl compounds, understanding their mechanisms and significance. Additionally, the course will delve into the world of carboxylic acids, unveiling their role in synthesis and practical applications. By the end, students will have the skills to design synthetic pathways and solve complex problems related to these diverse chemical compounds.	ents. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	

SCCH154	**Organic Chemistry-II Practicals**	L	T	P	C
Version 3.0		0	0	4	2
Total Contact Hours	30				
Pre-requisites/Exposure	Basics knowledge of organic compounds				
Co-requisites	--				

Course Objectives

1. To enable the students for hands on learning by experiments.
2. To generate confidence among students to perform reactions or analysis.

Course Outcomes

On completion of this course, the students will be able to

CO1. Understand the identification of elements and functional group of unknown organic compounds by sequential procedures.
CO2. Understand the organic synthesis by changing one compound into another.
CO3. Analyze the difference between green synthesis and conventional synthesis.
CO4. Learn about purification of substances.
CO5. Learn about the environment safety at the time of performing experiment.

Catalog Description

This course contains identification of elements and functional group of unknown organic compounds by sequential procedures. Acetylation, bromination, nitration, green synthesis, oxidation and reduction reactions are the major component of the syllabus.

Course Content

(List of experiments given are suggestive. One experiment from each group to be demonstrated)

1. Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.
2. Organic preparations:

i. Acetylationofoneofthefollowingcompounds:amines(aniline,*o*-,*m*-,*p*-toluidinesand*o*-,*m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method.and Using green chemistryapproach)

ii. Benzolyationofoneoftheamines(aniline,*o*-,*m*-,*p*-toluidinesand*o*-,*m*-,*p*-anisidine)andone of the phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumannreaction.

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Bromination (anyone)

a. Acetanilide by conventionalmethods

b. Acetanilide using green approach (Bromate-bromidemethod)

v. Nitration: (anyone)

a. Acetanilide/nitrobenzene by conventional method

b. Salicylic acid by green approach (using ceric ammoniumnitrate).

vi. Selective reduction of *meta*dinitrobenzene to *m*-nitroaniline.

vii. Reduction of *p*-nitrobenzaldehyde by sodiumborohydride.

viii. Hydrolysis of amides andesters.

ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone,benzaldehyde.

x. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid,oxalic acid, phenyl acetic acid and phthalicacid).

xi. Aldol condensation with either conventional or greenmethod.

xii. Benzil-Benzilic acidrearrangement.

Qualitative analysis of the following types of unknown organic compounds

(a) Carboxylic acids
(b) Phenols
(c) Alcohols
(d) Aldehydes
(e) Ketones
(f) Esters
(g) Carbohydrates
(h) Primary, secondary and tertiary amines
(i) Nitro compounds
(j) Amides

(k) Aryl halides
(l) Hydrocarbons
(m)Collected solid samples may be used for recrystallization, melting point and TLC.

Recommended Books/References:

1 O.P. Pandey, Practical Chemistry.
2 Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education(2009)
3 Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson(2012)
4 Ahluwalia,V.K.&Aggarwal,R.*ComprehensivePracticalOrganicChemistry:Preparationand Quantitative Analysis*, University Press(2000)
5 Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press(2000).

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Assessment & Evaluation

Components	**Quiz/Assignment/**	**Quiz/Assignment**	**Attendance**	**Mid Term Exam**	**End Term Exam**
Weightage (%)	**20**	10	10	20	50

Course Code and Title	**Course Outcome**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
SCCH154 ORGANIC CHEMISTRY-II PRACTICAL	**CO1**	**3**	**3**	**3**	**3**	**3**						**3**	**3**	**3**	**3**
	CO2	**3**	**3**	**3**	**3**	**3**						**3**	**3**	**3**	**3**
	CO3	**3**	**3**	**3**	**3**	**3**						**3**	**3**	**3**	**3**
	CO4	**3**	**3**	**3**	**3**	**3**						**3**	**3**	**3**	**3**
	CO5	**2**	**2**		**2**					**2**		**2**			

1=weakly mapped

2= moderately mapped

3=strongly mapped

Unit	1. Identification of elements (N, S, and halogen) and Functional group tests. 2. Organic preparations: i. Acetylation of amines Using green chemistry approach) ii. Benzolyation of amines and phenols by Schotten-Baumann reaction. iii. Oxidation of ethanol/ isopropanol (Iodoform reaction). iv. Bromination v. Nitration: (any one) vi. Selective reduction of meta dinitrobenzene to m-nitroaniline. vii. Reduction of p-nitrobenzaldehyde by sodium borohydride. viii. Hydrolysis of amides and esters. ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde. x. S-1.Identification of elements (N, S, and halogen) and Functional group tests. 2. Organic preparations: i. Acetylation of amines Using green chemistry approach) ii. Benzolyation of amines and phenols by Schotten-Baumann reaction. iii. Oxidation of ethanol/ isopropanol (Iodoform reaction). iv. Bromination v. Nitration: (any one) vi. Selective reduction of meta dinitrobenzene to m-nitroaniline. vii. Reduction of p-nitrobenzaldehyde by sodium borohydride. viii. Hydrolysis of amides and esters. ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde. x. S-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid). xi. Aldol condensation with either conventional or green method. xii. Benzil-Benzilic acid rearrangement.
Local	-
Regional	-
National	-
Global	The syllabus content is relevant at the regional level as it contributes to the development of regional laboratory capabilities and expertise in organic compound purification and analysis.
Employability	The practical skills gained from the organic preparations covered in the course content enhance employability by preparing students for careers in chemical industries, research and development, and analytical laboratories.
Entrepreneurship	-
Skill Development	The course content promotes skill development in organic chemistry, including practical techniques for organic preparations, identification tests, and chemical

	reactions. These skills are essential for a career in chemistry or related fields.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	The course content's relevance to environment and sustainability lies in the promotion of green chemistry approaches in organic preparations, which aim to minimize environmental impact and use sustainable practices.
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13)Optimal Learning Environments and Support for Students (12.1-12.10)
POE/4th IR	To provide practical sessions with variety of practicals/For Advanced technologies relevant to the chemicals industry student should have hands on exposure of lab processes for e.g. Compound Synthesis, titrations, quantitative and qualitative analysis etc.

Teaching Plan:

Weekly	**Topic/Unit No.**	**Textbook [TB]/**	**Teachi**
Week 1	Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.	**TB2**	Experiment
Week 2	Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.	**TB1**	Experiment
Week 3	Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.	**TB1**	Experiment
Week 4	Acetylationofoneofthefollowingcompounds:amines(aniline,*o*-,*m*-,*p*-toluidinesand*o*-,*m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method.and Using green chemistryapproach)	**TB1**	Experiment
Week 5	Acetylationofoneofthefollowingcompounds:amines(aniline,*o*-,*m*-,*p*-toluidinesand*o*-,*m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using	**TB2**	Experiment

	conventional method.and Using green chemistryapproach)		
Week 6	Benzoation of one of the amines(aniline,o-,m-,p-toluidinesando-,m-,p-anisidine)andone of the phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumannreaction.	**TB2**	Experi ment
Week 7	Salicylic acid by green approach (using ceric ammoniumnitrate).	**TB2**	Experi ment
Week 8	Acetanilide/nitrobenzene by conventional method	**TB2**	Experi ment
Week 9	Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone,benzaldehyde.	**TB2**	Experi ment
Week 10	Benzil-Benzilic acidrearrangement.	**TB2**	Experi ment
Week 11	Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.	**TB2**	Experi ment
Week 12	Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.	**TB2**	Experi ment
Week 13	Recap		Experi ment

Facilitating the Achievement of Course Learning Outcomes

Unit	**Course Learning Outcomes**	**Teaching**	**Assess**
1	In this series of experiments, students will acquire practical skills in organic chemistry. They will identify elements such as nitrogen, sulfur, and halogens in compounds while conducting functional group tests to differentiate between alcohols, phenols, carbonyl compounds, carboxylic acids, and amines. The experiments also encompass diverse organic preparations, involving reactions like acetylation of amines and phenols using both conventional and	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students begiven homework/assig	Experi ment

AEC002	New Age Life skills - II	**L**	**T**	**P**	**C**
Version 3.0		**3**	**0**	**0**	**3**
Total Contact Hours	**45**				
Pre-requisites/Exposure	**Basics of Chemistry**				
Co-requisites	--				

	environmentally friendly methods, as well as benzoylation, oxidation, bromination, nitration, selective reduction, and various other transformations. Students will learn purification techniques and utilize tools like recrystallization, melting point determination, and TLC analysis. These hands-on experiences will enhance their understanding of reaction mechanisms, regioselectivity, and the importance of green chemistry principles.	nments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	

COURSE OBJECTIVES:

- To cultivate and foster leadership skills and break barriers of communication.
- To enhance verbal ability competence and adaptability in learner.
- To enhance networking and relationship building skills in learner.
- To build need for self-awareness and personal development in learner.
- To inculcate different ways of preparing organizing and presenting their ideas

Course Outcomes (COs)

On completion of the course learner should be able to: -

- CO 1: Apply their communication skills in different professional and personal contexts, such as interviews, networking events, customer interactions, and interpersonal relationships.

- CO 2: Express ideas and information clearly and concisely through spoken language. They will develop the ability to articulate their thoughts, use appropriate vocabulary, and convey their message with clarity.
- CO 3: Develop skills related to career planning, job search strategies, and personal branding
- CO 4: Develop leadership skills and to motivate and inspire others, manage projects effectively, and demonstrate a proactive and responsible approach to their spoken language.

Catalogue Description:

The learners may be required to give presentation, engage in role plays, participate in group discussions, and complete written assessments to demonstrate their communication and skill development.Learner of such a course can expect to possess strong verbal and written communication skills, allowing them to express their thoughts and ideas clearly and concisely. The program fosters effective presentation skills, empowering graduates to deliver engaging and informative presentations. Learners will also acquire collaborative communication skills, facilitating teamwork and achieving shared goals.

Course Topics:

Unit 1: **Presentation and Public Speaking**

Structuring and organizing a presentation, Developing effective visual aids, Managing stage fright and anxiety, Engaging the audience and delivering impactful speeches

Unit 2: **Assertiveness and Confidence Building**

Developing self-confidence and self-esteem, Assertiveness techniques: expressing opinions, setting boundaries, and saying “no” effectively, Handling criticism and feedback.

Unit 3: **Teamwork and Collaboration**

Effective collaboration and cooperation, Conflict resolution within a team, Building trust and fostering a positive team culture

Unit 4: **Well-being and Mindfulness**

Promoting physical and mental well-being, Stress management techniques, Introduction to mindfulness and meditation practices

Text Book and References

Bayer, Mike (2019), Best Self
Gladwell Malcom, (2021), Talking to strangers
Scot Susan (2004), Fierce conversations

Mode of Evaluation:

Components	Quiz /Presentation/Assignment	Attendance	Mid Term	End Term
Weightage (%)	20	10	20	50

<u>Program Mapping – PO to CO's</u>

New Age Life skills – II

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PEO 1	PEO 2	PEO 3	PEO 4	PEO 5	PEO 6
CO 1								3										3		
CO 2										2										
CO 3													2							3
CO 4																				

1=lightly mapped 2= moderately mapped 3=strongly mapped

: Presentation and Public Speaking

Terms	Content Mapping
Local	Understanding the local context and preferences for effective presentation and public speaking.
Regional	Exploring the regional significance of engaging the audience and delivering impactful speeches.
National	Studying the national importance of structuring and organizing presentations for effective communication.
Global	Understanding the global impact of effective visual aids in presentations for diverse audiences.
Employability	Gaining presentation and public speaking skills relevant to employment and career advancement.
Entrepreneurship	Exploring the entrepreneurial importance of effective communication in business presentations.
Skill development	Developing skills in managing stage fright, organizing content, and engaging the audience effectively.
Professional ethics	Adhering to professional standards in delivering impactful speeches and presentations.
Gender	Encouraging equal participation and opportunities in the development of presentation and public speaking skills.
Human values	Fostering respect and understanding in communication for building strong connections with the audience.
Environment & sustainability	Promoting effective communication for a sustainable and collaborative work environment.

Unit 2: Assertiveness and Confidence Building

Terms	Content Mapping
Local	Developing self-confidence and assertiveness techniques within the local community and workplace.
Regional	Understanding the regional implications of setting boundaries and expressing opinions effectively.
National	Studying the national importance of handling criticism and feedback in personal and professional growth.
Global	Understanding the global impact of cultivating self-esteem and effective communication in diverse cultural settings.
Employability	Gaining assertiveness and confidence-building skills relevant to employment and career advancement.
Entrepreneurship	Exploring the entrepreneurial importance of effective communication and confidence in business settings.
Skill development	Developing skills in setting boundaries, handling criticism, and expressing opinions assertively.
Professional ethics	Adhering to professional standards in asserting opinions and setting boundaries with integrity.
Gender	Encouraging equal participation and opportunities in developing assertiveness and confidence-building skills.
Human values	Fostering personal growth and self-confidence while respecting diverse perspectives.
Environment & sustainability	Promoting a positive work environment through assertive and respectful communication.

Unit 3: Teamwork and Collaboration

Terms	Content Mapping
Local	Understanding the local dynamics of effective collaboration and conflict resolution within teams.
Regional	Exploring the regional significance of building trust and fostering a positive team culture.
National	Studying the national importance of effective teamwork and cooperation in diverse work settings.
Global	Understanding the global impact of teamwork and collaboration in diverse cultural and professional environments.
Employability	Gaining teamwork and collaboration skills relevant to employment and career advancement.
Entrepreneurship	Exploring the entrepreneurial importance of teamwork and cooperation for business success.
Skill development	Developing skills in conflict resolution, building trust, and fostering a positive team culture.
Professional ethics	Adhering to professional standards in promoting effective collaboration and teamwork.
Gender	Encouraging equal participation and opportunities in fostering teamwork and collaboration.
Human values	Fostering a sense of responsibility and professionalism in promoting effective teamwork and collaboration.
Environment &	Promoting a positive and collaborative work environment for sustainable growth

sustainability	and development.

Unit 4: Well-being and Mindfulness

Terms	Content Mapping
Local	Promoting physical and mental well-being within the local community and workplace.
Regional	Understanding the regional impact of stress management techniques and mindfulness practices.
National	Studying the national importance of well-being and mindfulness in personal and professional life.
Global	Understanding the global significance of stress management and mindfulness practices in diverse cultural settings.
Employability	Gaining well-being and mindfulness skills relevant to maintaining a healthy work-life balance.
Entrepreneurship	Exploring the entrepreneurial importance of promoting well-being and mindfulness in business settings.
Skill development	Developing skills in stress management, mindfulness, and maintaining a healthy work-life balance.
Professional ethics	Adhering to professional standards in promoting well-being and mindfulness in the workplace.
Gender	Encouraging equal participation and opportunities in promoting well-being and mindfulness practices.
Human values	Fostering personal growth and well-being while upholding values of respect and empathy.
Environment & sustainability	Promoting a healthy and balanced work environment for sustainable personal and professional growth.

SEC008	**Data Analysis and Visualization**	L	T	P	C
Version 1.0		2	0	0	2
Total Contact Hours	30				
Pre-requisites/Exposure	Basics of Python				
Co-requisites	--				

Course Objectives

- Acquire a deep understanding of NumPy and Pandas for efficient data manipulation.
- Excel in Data Visualization: Develop proficiency in creating and customizing data visualizations using Matplotlib, Pandas, and Seaborn.
- Apply Advanced Data Analysis: Apply advanced techniques such as conditional logic, correlation, and data handling for in-depth data exploration.
- Optimize Data Processes: Learn to evaluate and optimize data manipulation, visualization, and analysis to derive meaningful insights.

Course Outcomes

On completion of this course, the students will be able to learn:-

CO1. Mastery of Data Tools: Understand and apply NumPy and Pandas for efficient data manipulation and analysis.

CO2: Proficient Data Visualization: Master Matplotlib, Pandas, and Seaborn for creating and customizing various data visualizations.

CO3 Advanced Data Analysis: Apply advanced techniques, including conditional logic, correlation, and data handling.

CO4 Optimize Data Processes: Evaluate and enhance data manipulation, visualization, and analysis for efficient insights.

Catalog Description:

This course equips students with the essential skills for efficient data manipulation and visualization using Python libraries. Students will learn to work with NumPy and Pandas to handle and analyze data effectively, and master Matplotlib and Seaborn for creating a wide range of data visualizations. Advanced data analysis techniques will be covered, including conditional logic and data alignment. Students will also gain the ability to evaluate and optimize data processes to extract meaningful insights for decision-making. This course prepares students for data-driven tasks in various fields, including data analysis, research, and business intelligence.

Course Content

UNIT – I 7 Lectures

NumPy: Array and vectorized computation: Multidimensional array object. Creating ndarrays, arithmetic with numpy array, basic indexing and slicing, Boolean indexing, transposing array and swapping axes, universal functions, array-oriented programming with arrays, conditional logic as arrays operations, file input and output with array

UNIT -II 8 Lectures

Pandas: Pandas data structure, series, DataFrame, Index Object, Reindexing, dropping entities from an axis, indexing, selection and filtering, integer indexes, arithmetic and data alignment, function application and mapping, soring and ranking, correlation and covariance, unique values, values controls and membership, reading and writing data in text format

UNIT -III 8 Lectures

Visualization with Matplotlib: Figures and subplots, colors, markers, line style, ticks, labels, legends, annotation and drawing on sublots, matplotlib configuration

UNIT -IV 10 Lectures

Plotting with pandas and seaborn: line plots, bar plots, histogram, density plots, scatter and point plots, facet grids and categorical data

Text Books

Fabio Nelli, Python Data Analytics 2nd Edition, Apress.

Reference Books/Materials

1. Python for Data Analysis: A Complete Beginner Guide for Python basics, Numpy, Pandas,

Components	Assignment	Mid Term Examination	Attendance	End Term Examination
Weightage (%)	20	20	10	50

Seaborn, Bokeh and Matplotlib for Data Analysis, AI Publishing LLC.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Programme and Course Mapping

Course Code and Title	Course Outcomes (CO)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO1	PSO2	PSO3	PSO4
SEC008 Data Analysis and visualisation	CO1:	3	1	1	2	1	3	2	2	1	2	3	2	1	2
	CO2:	1	1	2	1	1	3	2	1	1	1	1	2	1	1
	CO3:	2	3	1	3	2	2	1	2	3	2	2	3	2	3
	CO4: s	1	2	1	2	2	1	2	1	2	3	1	2	1	2

1=weakly mapped

2= moderately mapped

3=strongly mapped

Unit I	Data Analysis and Visualization
Local	-
Regional	-
National	-
Global	-
Employability	-
Entrepreneurship	Student centric methods, such as experiential learning, participative

	learning and problem-solving methodologies (2.3.1)
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit II	
Local	-
Regional	-
National	-
Global	-
Employability	-
Entrepreneurship	Student centric methods, such as experiential learning, participative learningand problem-solving methodologies (2.3.1)
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit III	
Local	-
Regional	-
National	-
Global	Chemical composition of atmosphere
Employability	-
Entrepreneurship	-
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit IV	
Local	-
Regional	-
National	-
Global	-

Employability	-
Entrepreneurship	-
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
SDG	Skill for Decent Work; Sustainable Development and Global Citizenship
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Global Education Knowledge, imagination/creativity, assumption of responsibility and for making decisions, planning, coordinating and organising ability

Teaching Plan

Week	Topic/Unit No.	Textbook/Reference Book	Teaching-Learning Method
1	Introduction to Data Manipulation	TB - Chapter 1	Lecture, Discussion
2-3	NumPy Fundamentals	TB - Chapter 2	Lecture, Hands-on Exercises
4-5	Pandas for Data Management	TB - Chapter 3	Lecture, Practical Examples
6-7	Data Visualization with Matplotlib	TB - Chapter 4	Lecture, Visualization Exercises
8	Data Visualization with Pandas & Seaborn	TB - Chapter 5	Lecture, Practical Labs
9-10	Advanced Data Analysis	TB - Chapter 6	Lecture, Case Studies
11-12	Optimizing Data Processes	TB - Chapter 7	Lecture, Coding Challenges
13	Ethical Considerations in Data Analysis	RB - Chapter 8	Lecture, Ethical Discussions
14	Final Projects and Presentations	TB - Chapter 9	Project Work, Presentations

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Gain valuable hands-on experience in working with advanced materials and the associated equipment and techniques.	(i) Explanation of experiments with illustrations. (ii) Preparation of various inorganic compounds using different synthetic methods. (iii) Introduction to qualitative analysis techniques. (iv) Conducting titration experiments involving inorganic compounds for accurate measurements and concentration calculations.	• Experiment Performance and class discussions. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Develop critical skills required for scientific research, such as experimental design, data analysis, and effective communication of scientific findings.	- Activities related to experimental design and data analysis. - Effective communication of scientific findings.	• Research project reports and presentations. • Data analysis assignments. • Research project evaluation.

SEMESTER III

SCCH201	**Physical Chemistry-II**	L	T	p	C
Version 3.0		3	1	0	4
Total Contact Hours	**60**				
Pre-requisites/Exposure	Basics of Physical Chemistry (Upto class XII)				
Co-requisites	—				

Course Objectives

1. To explain the basic concepts of thermodynamics such as system, state, state postulate, equilibrium, properties, process and cycle
2. To distinguish between Open, Closed and Isolated systems, Microscopic and Macroscopic approaches, Intensive and Extensive properties
3. To define zeroth law of thermodynamics and explain the concept of pressure, temperature, specific volume and temperature scales.
4. To apply the above concepts to solve simple chemistry problems.

Course Outcomes

On completion of this course, the student-teacher will be able to:
CO1: describe the fundamental concepts of thermodynamics, including intensive and extensive variables, state and path functions, and isolated, closed, and open systems.
CO2: apply thermochemical principles to calculate heats of reactions, enthalpies of formation, and combustion for various molecules and ions.
CO3: integrate knowledge of partial molar quantities and Gibbs-Duhem equation to explain the dependence of thermodynamic parameters on composition.
CO4: demonstrate the application of thermodynamics in engineering, chemistry, and other real-world scenarios to make informed decisions and solve practical challenges.

Catalog Description
The topic of thermodynamics helps students in understanding the laws of thermodynamics and concepts. The concept of Partial molar quantities and its attributes relate properties to concentration. The knowledge of dilute solution and its properties helps students in understanding the concept of system, variables, heat, work, and laws of thermodynamics. The concept of heat of reactions and use of equations in calculations of bond energy, enthalpy, etc.enables students to make use of thermodynamics in day to day activities. The understanding of the concept of entropy; reversible, irreversible processes enables them to calculate entropy using 3rd law of thermodynamics. Joule Thompson effects, Gibbs- Helmholtz equation; Maxwell relations.makes a clear scenario of the daily routine appliances utilising the concept of thermodynamics. Four colligative properties: (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure explain the freezing of water, use of pressure cooker, removal of snow using solid carbon dioxide.
Course Content
Unit I: **15 Lectures**

Introduction to thermodynamics

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions**.**

Unit II: **15 Lectures**

Thermochemistry
Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions.Second Law, Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Unit III: 15 Lectures

Third law of thermodynamics

Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules.Free Energy Functions, Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversiontemperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Unit IV: 15 Lectures

Partial molar quantities

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Text Books

1 Atkins P. and De Paula, J. Physical Chemistry Tenth Ed., OUP, 2014. 2

2 Castellan, G. W. Physical Chemistry 4th Ed., Narosa, 2004.

Reference Books/Materials

1 Engel, T. and Reid, P. Physical Chemistry 3rd Ed., Prentice Hall, 2012.

2 McQuarrie, D. A. and Simon, J. D. Molecular Thermodynamics Viva Books, 2004.

3 Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001

4 Commonly Asked Questions in Thermodynamics. CRC Press, 2011.

5 Levine, I .N. Physical Chemistry 6th Ed., Tata Mc Graw Hill, 2010.

6 Metz, C.R. 2000 solved problems in chemistry, Schaum Series, 2006.

Open Educational Resources (OER)

- https://www.khanacademy.org/science/physics/thermodynamics
- https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/
- https://www.coursera.org/learn/thermodynamics-1
- https://phet.colorado.edu/en/simulations/category/physics/thermodynamics
- http://hyperphysics.phy-astr.gsu.edu/hbase/thermo.html
- https://chem.libretexts.org/Courses/Mount_Royal_University/Chem_1201/Unit_2%3A_Thermochemistry/Chapter_17%3A_Thermodynamics%3A_Four_Laws_that_Move_the_Universe
- https://www.youtube.com/playlist?list=PL8dPuuaLjXtPHzzYuWy6fYEaX9mQQ8oGr

- https://pressbooks.bccampus.ca/thermodynamics/
- http://chemcollective.org/vlabs
- https://demonstrations.wolfram.com/topic.html?topic=Thermodynamics

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz/Assignment/Presentation / Assignment	Attendance	Mid Term Exam	End Term Exam
Weightage (%)	20	10	20	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Course Code and Title	Course Outcomes (CO)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO1	PSO2	PSO3	PSO4
SCCH201 PHYSICAL CHEMISTRY-II	CO1	3	2	1	3	2	2	1	2	3	1	3	2	1	2
	CO2	2	3	1	2	2	3	2	2	2	2	2	1	3	1
	CO3	1	2	3	2	1	2	2	1	1	3	2	1	2	2
	CO4	2	1	2	3	2	2	2	2	1	1	3	3	2	3

1=weakly mapped
2= moderately mapped

3=strongly mapped

Unit I	Introduction to thermodynamics
Local	-
Regional	Applying thermodynamic concepts to regional engineering and processes.
National	-
Global	Engaging in global discussions on energy conservation and efficiency.
Employability	Building foundational knowledge for engineering and technical jobs.
Entrepreneurship	-
Skill Development	Developing problem-solving skills in thermodynamics.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	Thermochemistry
Local	-
Regional	-
National	-
Global	-
Employability	Identifying opportunities for energy-related businesses.
Entrepreneurship	-
Skill Development	Developing problem-solving skills in thermodynamics.
Professional Ethics	Promoting ethical practices in energy and chemical industries.
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Third law of thermodynamics
Local	-
Regional	-
National	-
Global	Engaging in global discussions on energy conservation and efficiency.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-

Human Values	-
Environment & Sustainability	-
Unit IV	Partial molar quantities
Local	-
Regional	-
National	Contributing to national-level understanding of energy conservation.
Global	-
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	; India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13)
POE/4th IR	Technical Skills that match Industry Needs

Teaching Plan:

Weekly Teaching Plan	Weekly Teaching Plan	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Method
Week 1	Introduction to Thermodynamics	Atkins & De Paula, Chapter 1	Lecture, Discussion
Week 2	Intensive and Extensive Variables	Atkins & De Paula, Chapter 2	Lecture, Problem-Solving
Week 3	State and Path Functions	Atkins & De Paula, Chapter 3	Lecture, Discussion
Week 4	Isolated, Closed, and Open Systems	Atkins & De Paula, Chapter 4	Lecture, Problem-Solving
Week 5	First Law of Thermodynamics	Atkins & De Paula, Chapter 5 Khan Academy - Thermodynamics	Lecture, Discussion, OER

Week 6	Enthalpy and Heat Capacities	Atkins & De Paula, Chapter 6 MIT OCW - Thermodynamics and Kinetics	Lecture, Problem-Solving
Week 7	Second Law of Thermodynamics	Atkins & De Paula, Chapter 7 Coursera - Thermodynamics for Engineers	Lecture, Discussion
Week 8	Entropy and its Interpretation	Atkins & De Paula, Chapter 8 PhET Simulations - Thermodynamics	Lecture, Problem-Solving
Week 9	Third Law of Thermodynamics	Atkins & De Paula, Chapter 9 HyperPhysics - Thermodynamics	Lecture, Discussion
Week 10	Gibbs and Helmholtz Energy	Atkins & De Paula, Chapter 10 LibreTexts - Fundamentals of Classical and Statistical	Lecture, Problem-Solving
Week 11	Chemical Potential and Ideal Mixtures	Atkins & De Paula, Chapter 11 Crash Course Chemistry: Thermochemistry	Lecture, Discussion
Week 12	Dilute Solutions and Colligative Properties	Atkins & De Paula, Chapter 12 BCcampus OpenEd - Thermodynamics eBook	Lecture, Problem-Solving
Week 13	Thermodynamic Derivations	Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics (Ch. 1)	Lecture, Discussion, OER
Week 14	Review and Problem-Solving	Review Chapters and Problem Sets from all Topics Metz - "2000 Solved Problems in	Lecture, Problem-Solving

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching-Learning Activity	Assessment Task Methods
1	• Understand the concepts of thermodynamics • Apply the first law of thermodynamics • Analyze different thermodynamic processes • Evaluate the efficiency of heat engines	• Lectures, Discussions, Visual Aids • Problem-Solving Sessions, Worked Examples • Case Studies, Group Activities • Laboratory	• Quizzes, Class Participation, Formative Assessments • Problem Sets, Homework, Practice Exercises • Group Presentations, Concept Maps, Midterm Exam

2	• Calculate heat of reactions and formation • Understand the concept of entropy • Analyze entropy change for reversible processes • Apply the second law of thermodynamics	• Lectures, Demonstrations, Interactive Whiteboard • Discussions, Thought Experiments, Videos • Problem-Solving Sessions, Thought Experiments	• Problem Sets, In-Class Quizzes, Homework • Class Discussions, Thought Papers, Formative Quizzes • Formative Assessments, Homework, Conceptual Quizzes • Group
3	• Understand the third law of thermodynamics • Analyze Gibbs and Helmholtz energy • Evaluate thermodynamic properties of mixtures • Apply	• Lectures, Discussions, Thought Experiments • Problem-Solving Sessions, Worked Examples • Laboratory Experiments, Simulation Activities	• Formative Quizzes, Class Participation, Homework • Problem Sets, Homework, In-Class Quizzes • Laboratory Reports, Simulation Results, Final Exam
4	• Analyze partial molar quantities • Understand the properties of dilute solutions • Apply thermodynamic principles to solve problems • Demonstrate	• Lectures, Group Discussions, Real-world Examples • Problem-Solving Sessions, Worked Examples • Laboratory Experiments, Simulation Activities,	• Group Presentations, Case Studies, Homework • Problem Sets, Homework, Formative Assessments • Laboratory Reports, Simulation Results, Final Exam

SCCH251	**Physical Chemistry-II Practicals**	L	T	P	C
Version 3.0		0	0	4	2
Total Contact Hours	30				
Pre-requisites/Exposure	Basics of Physical Chemistry				
Co-requisites	--				

Course Objectives

1. To perform time-bound experiments in order to do kinetic studies.
2. To learn about equilibrium and study it experimentally.
3. To understand physical parameters like, critical solution temperature, and distribution coefficient.

3. To observe the phenomenon of adsorption using activated charcoal.

Course Outcomes

On completion of this course, the student-teacher will be able to:

CO1: recall the critical solution temperature and composition of the phenol-water system.
Identify the effect of impurities on the critical solution temperature of the phenol-water system.

CO2: explain the equilibrium of the given chemical reactions using the distribution method.
Compare and contrast the equilibrium constants and distribution coefficients for the reactions.

CO3: apply the principles of kinetics to analyze and interpret the experimental data of acid hydrolysis and saponification reactions.

CO4: critically evaluate the results obtained from the adsorption experiments and draw meaningful conclusions.

Catalog Descriptio

This course imparts the basic concepts and protocols of experiments based on distribution method, equilibrium, and chemical kinetics. It enables them to experimentally work out physical parameters, like, critical solution temperature, and partition coefficient. It also discusses about the theory of adsorption and method to confirm Freundlich and Langmuir isotherm.

Course Content

List of Experiments

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
2. Study the equilibrium of at least one of the following reactions by the distribution method:
(i) I_2 (aq) + I^- → I_3^- (aq)
(ii) Cu $^{2+}$ (aq) + nNH_3 → $Cu(NH_3)_n$
3. Study the kinetics of the following reactions.
a. Acid hydrolysis of methyl acetate with hydrochloric acid.
b. Saponification of ethyl acetate.
4. Adsorption: Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid and selected organic dye(s) on activated charcoal.
(Use of calorimeter for calculation of heat of reactions may be demonstrated)

5. (I) Thermochemistry

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).

(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
(c) Calculation of the enthalpy of ionization of ethanoic acid.
(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.

(e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
(f) Determination of enthalpy of hydration of copper sulphate.
(g) Study of the solubility of benzoic acid in water and determination of ΔH.

Practical Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand, New Delhi, 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry, Eighth Edition, McGraw-Hill(2003).
3. Halpern, A. M. and McBane, G. C. Experimental Physical Chemistry, Third Edition, W, H. Freeman (2003).

Open Educational Resources (OER)

- http://chemcollective.org/
- https://www.khanacademy.org/science/chemistry
- https://chem.libretexts.org/
- https://ocw.mit.edu/courses/chemistry/
- https://www.youtube.com/user/TheOrganicChemistry
- https://pubchem.ncbi.nlm.nih.gov/
- http://www.chemcollective.org/vlabs

Modes of Evaluation: Quiz/Assignment/ presentation/ etempore/ Written Examination
Examination Scheme:

Components	Quiz/Assignment	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Program andCourse mapping

Course code and Title	Course Outcomes (COs)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO1	PSO2	PSO3	PSO4
SCCH	CO1:	3	2	1	3	1	2	1	3	3	2	3	3	2	2

251 Physical Chemistry-I Practicals	**CO2:**	**3**	**3**	**1**	**3**	**1**	**2**	**1**	**3**	**3**	**2**	**3**	**2**	**3**	**1**
	CO3:	**3**	**3**	**1**	**3**	**1**	**2**	**1**	**3**	**3**	**2**	**3**	**2**	**3**	**3**
	CO4:	**2**	**2**	**2**	**3**	**1**	**2**	**2**	**3**	**2**	**3**	**3**	**3**	**3**	**2**

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	1.Determination of critical solution temperature and composition 2. Study the equilibrium of reactions by the distribution method 3. Study the kinetics of reactions. 4. Adsorption: Verification of Freundlich and Langmuir isotherms
Local	-
Regional	-
National	-
Global	1.Determination of critical solution temperature and composition 2. Study the equilibrium of reactions by the distribution method 3. Study the kinetics of reactions. 4. Adsorption: Verification of Freundlich and Langmuir isotherms
Employability	-
Entrepreneurship	-
Skill Development	Use of simple instruments like viscometer and stalagmometer, working theory behind a pH-meter, and how to carry out measurements and pH-metric titrations. Basic concepts about buffer solutions
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Universal quality education and lifelong learning(SDG 4.4)
NEP	India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13)
POE/4th IR	Technical Skills that match Industry Needs

Teaching Plan:

Weekly Teaching Plan	Topics / Unit No.	Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ Open Education Resources [OER]	Teaching & Learning Methods
Week 1	Introduction to Physical Chemistry	Garland, C.W. et al. (Ch. 1), Khan Academy, Chem LibreTexts	Lecture, Discussion, Khan Academy

Week 2	The Gaseous State	Khosla et al. (Ch. 1), OCW MIT, YouTube (Organic Chem)	Lecture, Problem Solving, Videos
Week 3	First Law of Thermodynamics	Halpern & McBane (Ch. 2), Khan Academy, ChemCollective	Lecture, Lab Experiments, Simulations
Week 4	Second Law of Thermodynamics	Garland, C.W. et al. (Ch. 5), Khan Academy, Chem LibreTexts	Lecture, Problem Solving, Activities
Week 5	Chemical Kinetics	Khosla et al. (Ch. 6), OCW MIT, YouTube (Organic Chem)	Lecture, Lab Work, Problem Sets
Week 6	Chemical Equilibrium	Garland, C.W. et al. (Ch. 6), Khan Academy, ChemCollective	Lecture, Case Studies, Simulations
Week 7	Acid-Base Equilibria	Halpern & McBane (Ch. 5), Khan Academy, Chem LibreTexts	Lecture, Problem Solving, Activities
Week 8	Thermodynamics and Equilibrium	Khosla et al. (Ch. 2), OCW MIT, YouTube (Organic Chem)	Lecture, Lab Work, Problem Sets
Week 9	Chemical Thermodynamics	Garland, C.W. et al. (Ch. 9), Khan Academy, ChemCollective	Lecture, Case Studies, Simulations
Week 10	Phase Equilibria and Solutions	Garland, C.W. et al. (Ch. 10), Khan Academy, Chem LibreTexts	Lecture, Problem Solving, Activities
Week 11	Electrochemistry	Halpern & McBane (Ch. 6), OCW MIT, YouTube (Organic Chem)	Lecture, Lab Work, Problem Sets
Week 12	Chemical Kinetics and Catalysis	Garland, C.W. et al. (Ch. 8), Khan Academy, ChemCollective	Lecture, Case Studies, Simulations
Week 13	Molecular Spectroscopy	Halpern & McBane (Ch. 7), Khan Academy, Chem LibreTexts	Lecture, Lab Experiments, Videos
Week 14	Review and Final Exam	Comprehensive Review of Course Material, Khan Academy, Chem LibreTexts	Review, Final Examination

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes (CO))	Teaching-Learning Activities	Assessment Task Methods

1	1. Understand the concept of critical solution temperature. 2. Analyze the effect of impurities on critical solution temperature. 3. Determine the composition of the phenol-water system at its critical point.	- Lecture on critical solution temperature. - Conduct experiments with impurities. - Lab experiments to determine composition.	- Quiz on critical solution temperature. - Lab reports and observations. - Lab reports and composition calculations.
2	1. Study the equilibrium of the specified chemical reactions. 2. Analyze the factors affecting the equilibrium.	- Conduct experiments using the distribution method. - Vary conditions and analyze the effects.	- Lab reports and calculations. - Data analysis and reports.
3	1. Understand the principles of chemical kinetics. 2. Study the kinetics of acid hydrolysis of methyl acetate. 3. Investigate the saponification of ethyl acetate.	- Lectures on kinetics and reaction rates. - Conduct experiments and data collection. - Experimental setup and observations.	- Quiz on kinetics principles. - Lab reports and reaction rate calculations. - Lab reports and data analysis.
4	1. Study the adsorption of acetic acid and organic dye on activated charcoal. 2. Verify Freundlich and Langmuir isotherms.	- Perform adsorption experiments. - Analysis of adsorption data and isotherms.	- Lab reports and adsorption isotherm calculations. - Data analysis and isotherm verification.

SCCH203	**ORGANIC CHEMISTRY-III**	L	T	P	C
Version 3.0		3	1	0	4
Total Contact Hours	60				
Pre-requisites/Exposure	Basics of organic chemistry and reaction mechanism				
Co-requisites	--				

Course Objectives

1. To enable the students to understand Nitrogen containing functional groups and their reactions.
2. To familiarize the students with poly nuclear hydrocarbons and their reactions.
3. To enable the students to understand Heterocyclic compounds and their reactions.
4. Classification, structure, mechanism of reactions of few selected alkaloids and terpenes.

Course Outcomes

On completion of this course, the students will be able to

CO1. Enhance the skill of learning about synthesis and reactions of amines

CO2. Study the applications of polynuclear hydrocarbon

CO3. Learn the concepts of heterocyclic chemistry, its reactions and applications in various fields.

CO4. Develop of problem solving capacity with respect to organic reaction and mechanism

CO5. Understand and evaluate applications of alkaloids and terpenoids available in nature

CO6. Compare the reactivity of heterocyclic compounds and propose mechanism of reactions

Catalog Description

This course contains structure, stability, methods of synthesis and reactions of amine and their derivatives. The importance of polynuclear hydrocarbon discussed with applications. The course will apprise students about the synthesis, reactions and mechanism of substitution reactions of five membered and six membered heterocycles like furan, pyrrole, pyridine, thiophene and indole etc. This course also comprise of some natural products as alkaloids and terpenes.

Course Content

UNIT I

Nitrogen Containing Functional Groups **15 Lectures**

Preparationandimportantreactionsofnitroandcompounds,nitrilesandisonitrilesAmines:Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann- elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium salts: Preparation and syntheticapplications.

UNIT II

Polynuclear Hydrocarbons **15 Lectures**

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

UNIT III Heterocyclic Compounds **15 Lectures**

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containingoneheteroatom;Synthesis,reactionsandmechanismofsubstitutionreactionsofFuran, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler- Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoicacid.

UNIT IV Alkaloids **15 Lectures**

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.Terpenes: Occurrence,classification,isoprenerule;Elucidationof structure andsynthesisofCitral,Neraland α-terpineol.

Recommended Text Books/references:

1. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7thEdn., Pearson.
2. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, John Welly & Sons (1976).
3. Solomons, T.W., Fryhle Craig, *Organic Chemistry*, John Wiley & Sons, Inc(2009).
4. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
5. Kalsi, P. S. *Organic reactions and their mechanisms*, New Age Science(2010).
6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford UniversityPress Inc., New York(2001).
7. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan(2010).
8. Bansal R. K. *Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms*, New Age, Third Edition (1999).

Open Educational Resources (OER)

- **https://www.khanacademy.org/science/organic-chemistry/amines/amines-tutorial**
- **http://www.chemguide.co.uk/mechanisms/nitro/mechanisms.html**
- **http://chemcollective.org/**
- **http://chemcollective.org/**
- **http://www.chemguide.co.uk/basicorg/conventions/heterocyclic.html**
- **http://www.chemguide.co.uk/basicorg/conventions/alkaloids.html**
- **https://www.rsc.org/Education/teachers/learnnet/terpenes/index.htm**

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	**Assignment/P**	**Mid Term Examination**	**Attendance**	**End Term Examination**
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course Code and Title	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SCCH203 Organic Chemistry-III	CO1	3										3			
	CO2			3									3		
	CO3		2	3								3			
	CO4	3					1					3			
	CO5	3						1				3			2
	CO6	3										3		2	

Unit I	Nitrogen Containing Functional Groups
Local	-
Regional	-
National	-
Global	Understanding nitrogen-containing functional groups, polynuclear hydrocarbons, heterocyclic compounds, and alkaloids has global relevance as it contributes to the global knowledge base of organic chemistry and its applications in various industries, including pharmaceuticals and biotechnology.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	**Heterocyclic Compounds**
Local	-
Regional	-
National	-
Global	Understanding nitrogen-containing functional groups, polynuclear hydrocarbons, heterocyclic compounds, and alkaloids has global relevance as it contributes to the

	global knowledge base of organic chemistry and its applications in various industries, including pharmaceuticals and biotechnology.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Polynuclear Hydrocarbons
Local	-
Regional	-
National	-
Global	Understanding nitrogen-containing functional groups, polynuclear hydrocarbons, heterocyclic compounds, and alkaloids has global relevance as it contributes to the global knowledge base of organic chemistry and its applications in various industries, including pharmaceuticals and biotechnology.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Alkaloids and Terpenes
Local	-
Regional	-
National	-
Global	Understanding nitrogen-containing functional groups, polynuclear hydrocarbons, heterocyclic compounds, and alkaloids has global relevance as it contributes to the global knowledge base of organic chemistry and its applications in various industries, including pharmaceuticals and biotechnology.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional	-

Ethics	
Gender	-
Human Values	-
Environment &Sustainability	-
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education 1.1- 11.13)
POE/4th IR	Skill Embedded Courses Development (Chemical analyst, Chemical manufacturing industry: Pharmeceutical Industry etc.)

Teaching Plan:

Weekly Teac	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources	Teaching-Learning Method
Week 1	Introduction of Heterocyclic compounds Preparation and important reactions of nitro compounds	Advanced Organic Chemistry by Bahl and Bahl- 835-843	Black board teaching, Presentations,
Week 2	Preparation and important reactions of nitriles and isonitriles	Advanced Organic Chemistry by Bahl and Bahl- 844	Black board teaching, Assignment
Week 3	Introduction of Amines, Nomenclature and concept of basicity, Discussion on Amine Synthesis, Discussion on	Advanced Organic Chemistry by Bahl and Bahl-762-795	Black board teaching, Problem -solving
Week 4	Diazonium salts: Preparation and synthetic applications, Problems related to Nitrogen containing compounds	Advanced Organic Chemistry by Bahl and Bahl- 1116-1157	Black board teaching, Presentations,
Week 5	Structure, Preparation and structure elucidation, reactions of naphthalene, and anthracene	Advanced Organic Chemistry by Bahl and Bahl-1278-1306	Presentation and Quiz
Week 6	Structure, Preparation and structure elucidation, reactions of phenanthrene	Advanced Organic Chemistry by Bahl and Bahl-1307-1313	Black board teaching and Presentation
Week 7	Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings	Advanced Organic Chemistry by Bahl and Bahl-1314-1361	Black board teaching, Problem -solving
Week 8	Synthesis, and reactions of Pyrrole and thiophene	Advanced Organic Chemistry by Bahl and Bahl-1314-1361 Morrison, R. T., Boyd, R. N.,	Black board teaching, Assignment

Week 9	Discussion about Pyridine, Pyrimidine, Structure elucidation of indole, Fischer indole synthesis	Advanced Organic Chemistry by Bahl and Bahl-1314-1361	Black board teaching, Assignment,
Week 10	Structure elucidation of quinoline and isoquinoline, (Skraup synthesis, Friedlander's synthesis,	Advanced Organic Chemistry by Bahl and Bahl-1314-1361	Black board teaching, Quiz, Problem solving
Week 11	Natural occurrence, General structural features, Isolation and their physiological action	Advanced Organic Chemistry by Bahl and Bahl-1375-1398 Synthesis of nicotine:	Presentation, Quiz, Assignment
Week 12	Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral,	Advanced Organic Chemistry by Bahl and Bahl-1399-1421 Morrison, R. T., Boyd, R. N.,	Black board Teaching, Quiz
Week 13	Revision		Doubt clearing session, Problem solving approach

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Enhance the skill of learning about synthesis and reactions	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be	• Presentations and class discussions • Assignments and class tests • Student presentations • Mid-term examinations. • Quiz. • End-term examinations
2	Study the applications of polynuclear hydrocarbon		
3	Learn the concepts of heterocyclic chemistry, its reactions and		
4	Develop of problem-solving capacity with respect to organic		
5	Understand and evaluate applications of alkaloids and		

6	Compare the reactivity of heterocyclic compounds and	encouraged to apply concepts to real world problems.	

SCCH253	ORGANIC CHEMISTRY-III PRACTICAL	L	T	P	C
Version 3.0		0	0	4	2
Total Contact Hours	30				
Pre-requisites/Exposure	Basics of organic chemistry and reaction mechanism				
Co-requisites	--				

Course Objectives

1. To enable the student for hands on learning by experiments.
2.To generate confidence among students to perform reactions or analysis.

Course Outcomes

On completion of this course, the students will be able to

CO1. Learn Qualitative analysis of unknown organic compounds.

CO2. Learn Qualitative analysis of functional groups of unknown organic compounds.

CO3. Application of Spectroscopy for identification of simple organic compounds.

CO4. Understand the preparation of indicators.

CO5. Learn the extraction of natural products.

CO6. Learn about the environment safety at the time of performing experiment.

Catalog Description

This course gives idea about Qualitative analysis of unknown organic compounds by simple and spectroscopic methods. The preparation of Methyl Orange and extraction of caffeine are some innovative approach of this syllabus. This syllabus also provides exposure towards analysis of carbohydrates.

Course Content

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols,etc.

2.Identification of functional groups of simple organic compounds by IR spectroscopy andNMR spectroscopy (IR and NMR of simple organic compounds may be done wherever facilities are available, otherwise sample spectra may be provided for simple organic compounds like Ethanol, Aniline, Phenol, acetic acid, other simple aldehydes, carboxylic acid, etc., for identification of functional groups. References from standard spectroscopy books may also be taken for such purpose for enhancing students understanding andskill).

3. Preparation of methyl orange.
4. Extraction of caffeine from tealeaves.
5. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars usingsimple labprocedures.

Organic preparations

6. Acetylation of amines and phenols
7. Benzolyation of amines and phenols by Schotten-Baumann reaction
8. Hydrolysis of amides and esters to obtain benzoic acid.
9. 2,4-DNP, semicarbazone and oxime derivative of carbonyl compound
10. Nitration of nitrobenzene, chlorobenzene & bromobenzene
11. Oxidation of the benzaldehyde, benzyl alcohol, acetophenone to benzoic

Recommended Books/References:

1. Vogel, A.I. *Quantitative Organic Analysis*, Part 3, Pearson(2012).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education(2009)
3. Furniss,B.S.;Hannaford,A.J.;Smith,P.W.G.;Tatchell,A.R.*PracticalOrganicChemistry,5th Ed.*, Pearson(2012)
4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press(2000).
5. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press(2000).

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Open Educational Resources (OER)

- **https://www.organic-chemistry.org/**
- **http://www.chemguide.co.uk/mechanisms/menu.html**
- **https://www.rsc.org/Education/teachers/learnnet/pdf/organic/carbohydrate_analysis.pdf**
- **http://chemcollective.org/**
- **http://www.chemguide.co.uk/analysis/group7.html**
- **https://learn.saylor.org/course/view.php?id=11**

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	**Conduct of Experiment**	**Lab Record/Quizzes/ Viva-Voce**	**Attendance**	**End Term Practical Examination**
Weightage (%)	**20**	**20**	**10**	**50**

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Course Code and Title	**Course Outcome**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
SCCH253 Organic Chemistry-III PRACTICAL	**CO1**	**3**										**3**			
	CO2			**3**									**3**		
	CO3		**2**	**3**								**3**			
	CO4	**3**					**1**					**3**			
	CO5	**3**						**1**				**3**			**2**
	CO6	**3**										**3**		**2**	

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	1. Qualitative analysis of unknown organic compound 2. Identification of functional groups 3. Preparation of methyl orange. 4. Extraction of caffeine from tea leaves. 5. Analysis of Carbohydrate
Local	-
Regional	-
National	-
Global	Understanding qualitative analysis techniques, spectroscopy, and the analysis of organic compounds has global relevance as it contributes to the global knowledge base in chemistry, scientific research, and the development of new analytical

	methods.
Employability	The practical skills gained from qualitative analysis, spectroscopy, and the analysis of organic compounds enhance employability by preparing students for careers in chemical analysis, quality control, research laboratories, and related fields where these skills are valuable.
Entrepreneurship	-
Skill Development	The course content promotes skill development in qualitative analysis techniques, spectroscopy, and the analysis of organic compounds, providing students with practical skills necessary for a career in chemical analysis and research.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	The knowledge gained from the analysis of organic compounds can contribute to environmental studies, particularly in analyzing organic pollutants or monitoring chemical processes that impact the environment.
SDG	Universal quality education and lifelong learning(SDG 4.4)
NEP	India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13)Optimal Learning Environments and Support for Students (12.1-12.10)
POE/4th IR	To provide practical sessions with variety of practicals

Teaching Plan:

Week	Topic	Reference Books/Texts	Teaching-Learning Methods
1	Introduction to Organic Qualitative Analysis	Mann & Saunders, Practical Organic Chemistry	Lecture, discussion of laboratory safety and equipment, introduction to qualitative analysis techniques.
2	Carbohydrates Analysis	Ahluwalia & Dhingra, Comprehensive Practical Org. Chem.	Lecture on carbohydrates, practical lab session for qualitative analysis of carbohydrates.
3	Aromatic Hydrocarbons	Mann & Saunders, Practical Organic Chemistry	Lecture on aromatic hydrocarbons, practical lab session for qualitative analysis.
4	Nitro Compounds	Vogel, Quantitative Organic Analysis	Lecture on nitro compounds, practical lab session for qualitative analysis.
5	Amines and Amides	Vogel, Quantitative Organic Analysis	Lecture on amines and amides, practical lab session for qualitative analysis.
6	Aryl Halides	Vogel, Quantitative Organic Analysis	Lecture on aryl halides, practical lab session for qualitative analysis.

7	Spectroscopy Techniques	SpectraSchool, MIT OpenCourseWare	Introduction to IR and NMR spectroscopy, interpretation of spectra.
8	Simple Organic Compound Identification (IR/NMR)	SpectraSchool, OpenCourseWare	Lab session to identify functional groups using IR and NMR spectra.
9	Preparation of Methyl Orange	Mann & Saunders, Practical Organic Chemistry	Lecture and practical session on the preparation of methyl orange.
10	Extraction of Caffeine from Tea Leaves	Mann & Saunders, Practical Organic Chemistry	Lecture and practical session on caffeine extraction.
11	Analysis of Carbohydrates (Reducing/Non-Reducing)	Ahluwalia & Dhingra, Comprehensive Practical Org. Chem.	Lab session for the analysis of reducing and non-reducing sugars.
12	Organic Preparations: Acetylation and Benzoylation	Vogel, Practical Organic Analysis	Lecture on acetylation and benzoylation, practical lab sessions for these preparations.
13	Hydrolysis of Amides and Esters	Vogel, Practical Organic Analysis	Lecture on hydrolysis reactions, practical lab session for obtaining benzoic acid.
14	Derivatives of Carbonyl Compounds	Vogel, Practical Organic Analysis	Lecture on 2,4-DNP, semicarbazone, and oxime derivatives, practical lab session.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	CLO	Teaching-Learning Activities	Assessment Task Methods
1	CLO 1: Understand the principles and techniques of qualitative analysis in organic chemistry. CLO 2: Demonstrate the ability to identify and distinguish different	- Lecture and discussion on qualitative analysis techniques. - Hands-on practice of qualitative analysis in the laboratory. - Interpretation of IR and NMR spectra in practical sessions. - Group discussions on identifying	- Lab reports assessing the accuracy of qualitative analysis. - Written exam on the principles of qualitative analysis. - Submission of a report on the interpretation of spectra. - Practical assessment based on
II	CLO 1: Understand the principles of IR and NMR spectroscopy in organic compound analysis. CLO 2: Apply IR and NMR spectroscopy to identify functional groups in organic	- Lectures on the theory and principles of IR and NMR spectroscopy. - Interpretation of sample spectra. - Practical sessions on interpreting IR and NMR spectra for simple organic compounds. -	- Written exam assessing understanding of spectroscopy principles. - In-class quizzes on spectra interpretation. - Assessment of individual ability to interpret spectra. - Group projects where students

COURSE

AEC003	New Age Life skills - I	**L**	**T**	**P**	**C**
Version 3.0		**3**	**0**	**0**	**3**
Total Contact Hours	**45**				
Pre-requisites/Exposure	**Basics of Chemistry**				
Co-requisites	--				

OBJECTIVES:

- To develop goal-setting and planning Skills to achieve academic and personal objective
- To improve research and information literacy skills to gather and evaluate credible sources
- To develop networking skills to build connection with mentors and professionals in chosen field.
- To develop leadership qualities to take initiative inspire others and contribute positively.
- To have a standard resume and social media profile to navigate resources platforms and tools effectively.

Course Outcomes (COs)

On completion of the course learner should be able to: -

- COS1 Seek opportunities to exploit and further develop their knowledge.
- CO2 Exercise professional knowledge and encourage in development of speaking skills.
- CO3 Develop different value systems and moral dimensions in taking decisions.
- CO4 Collaborate and lead colleagues, using a range of practical, facilitative, communication and networking skills to influence practice and policy in diverse environments.
- CO5 Exhibit competence in utilization and application

Catalogue Description:

This course aims to equip individuals with the essential abilities to effectively communicate in various professional contexts. Ethical communication practices, critical thinking, adaptability, professionalism, and a commitment to self-reflection and growth are other outcomes of the program. Overall, a Communication Skills program empowers individuals with the skills necessary for success in various professional environments.

Unit 1: **Financial Literacy**

Understanding Money Budgeting and Saving, Investing and Wealth Management Retirement Plan

Unit 2: **Emotional Intelligence**

Understanding and managing emotions, Empathy and social awareness, Building and maintaining positive relationships, Conflict resolution and negotiation skills

Unit 3: **Introduction to Time Management**

Understanding the importance of time management, Exploring common time management challenges, Benefits of effective time management

Unit 4: **Digital Literacy and Online Etiquette**

Navigating the digital world safely and responsibly, Understanding online privacy and security, Developing good online etiquette and building a positive digital presence, CV/ Resume, GDPI, Online Profile Building

Text Book and References:

O'Hanlon,bill, (2012) The change your life book
Gladwell Malcom, (2021), Talking to strangers
Scot Susan (2004), Fierce conversations

Mode of Evaluation:

Components	Quiz 1	Attendance	Mid Term	Presentation/Assignment	End Term
Weightage (%)	10	10	20	10	50

Unit 1: Financial Literacy

Terms	Content Mapping
Local	Understanding local financial practices and implications of budgeting, saving, and investing.
Regional	Exploring regional wealth management strategies and retirement planning for financial security.
National	Studying national financial regulations and policies impacting money management and investment.
Global	Understanding global financial markets and the importance of financial literacy in a global economy.
Employability	Gaining financial literacy skills relevant to employment and personal financial growth.
Entrepreneurship	Exploring the entrepreneurial importance of effective money management and investment strategies.

Skill development	Developing skills in budgeting, investing, and planning for retirement and financial security.
Professional ethics	Adhering to professional standards in financial management and wealth planning.
Gender	Encouraging equal financial literacy and empowerment for all genders.
Human values	Fostering responsible financial practices and understanding the ethical aspects of wealth management.
Environment & sustainability	Promoting sustainable financial practices for a secure and balanced economy.

Unit 2: Emotional Intelligence

Terms	Content Mapping
Local	Understanding local emotional dynamics and managing emotions effectively in personal and professional settings.
Regional	Exploring the regional significance of empathy and building positive relationships for effective communication.
National	Studying the national importance of conflict resolution and negotiation skills in diverse contexts.
Global	Understanding the global impact of emotional intelligence in fostering cooperation and understanding across cultures.
Employability	Gaining emotional intelligence skills relevant to employment and career advancement.
Entrepreneurship	Exploring the entrepreneurial importance of empathy and effective communication in business settings.
Skill development	Developing skills in managing emotions, building relationships, and resolving conflicts effectively.
Professional ethics	Adhering to professional standards in promoting emotional intelligence and positive relationships.
Gender	Encouraging equal emotional intelligence and interpersonal skills development for all genders.
Human values	Fostering empathy and understanding while upholding values of respect and integrity.
Environment & sustainability	Promoting a positive and cooperative work environment through emotional intelligence.

Unit 3: Introduction to Time Management

Terms	Content Mapping
Local	Understanding the local importance of time management in personal and professional life.
Regional	Exploring regional time management challenges and solutions for effective productivity and balance.
National	Studying national time management strategies and their impact on personal and professional growth.
Global	Understanding the global significance of effective time management in diverse work environments.
Employability	Gaining time management skills relevant to employment and career advancement.
Entrepreneurship	Exploring the entrepreneurial importance of effective time management for business success.
Skill development	Developing skills in prioritization, scheduling, and effective utilization of time

	for productivity.
Professional ethics	Adhering to professional standards in time management and meeting deadlines efficiently.
Gender	Encouraging equal participation and opportunities in developing effective time management skills.
Human values	Fostering a balanced work-life schedule and respecting the importance of personal time.
Environment & sustainability	Promoting a healthy work environment through effective time management practices.

Unit 4: Digital Literacy and Online Etiquette

Terms	Content Mapping
Local	Navigating the local digital world safely and responsibly, understanding the implications of online activities.
Regional	Exploring regional online privacy and security concerns and their impact on digital behavior.
National	Studying national policies and regulations concerning digital literacy and responsible online behavior.
Global	Understanding global online etiquette and building a positive digital presence in diverse cultural settings.
Employability	Gaining digital literacy skills relevant to employment and career advancement in the digital age.
Entrepreneurship	Exploring the entrepreneurial importance of building a positive online presence for business success.
Skill development	Developing skills in online privacy, security, and effective communication in digital environments.
Professional ethics	Adhering to professional standards in online communication and building a responsible digital profile.
Gender	Encouraging equal participation and opportunities in developing digital literacy and online etiquette.
Human values	Fostering responsible online behavior and upholding values of respect and integrity in the digital world.
Environment & sustainability	Promoting a safe and secure digital environment for sustainable growth and development.

SEMESTER IV

SCCH202	**Physical Chemistry-III**	L	T	P	C

Version 4.0		3	1	0	4
Total Contact Hours	**60**				
Pre-requisites/Exposure	**Basics of Chemistry**				
Co-requisites	**--**				

Course Objectives

1. To be able to derive Gibbs phase rule and apply it to calculate degrees of freedom.
2. To learn about different terms and equations related to chemical kinetics.
3. To be able to write mathematical expressions for adsorption isotherms.
4. To understand enzyme catalysis and derive relevant equations for Michaelis- Menten mechanism.

Course Outcomes

On completion of this course, the student-teacher will be able to:

CO1: demonstrate an understanding of the fundamental concepts of phase equilibria.

CO2: analyse and interpret phase diagrams for one-component and multi-component systems, solutions.

CO3: analyse complex chemical kinetics and reaction mechanisms, rates.

CO4: develop a comprehensive understanding of catalysis.

Catalog Description

The course explains the basic concepts as Phases, components, Gibbs phase rule, Phase diagrams andapplications. It enables the students to understand chemicalkinetics, typeofreactions,determinationofrate,theoriesofreactionrate,steady stateapproximation. It will help the students to work out the order and molecularity. The course will explain the kinetics of complex reactions with the help of suitable examples. It also explains the concept of catalysis, along with enzyme catalysis. Finally, the students will learn about different aspects of adsorption.

Course Content

Unit I: **15 Lectures**

Phase Equilibria

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactiveandreactivesystems;Clausius-Clapeyronequationanditsapplicationstosolid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications.Phasediagramsforsystemsofsolid-liquidequilibriainvolvingeutectic,congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform- acetic acid system, triangular plots. *Binary solutions:* Gibbs-Duhem-Margules equation, its derivationandapplicationstofractionaldistillationofbinarymiscibleliquids(idealandnonideal), azeotropes,leverrule,partialmiscibilityofliquids,CST,misciblepairs,steamdistillation.Nernst distribution law: its derivation andapplications.

Unit II: **15 Lectures**

Chemical Kinetics

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated rate laws for first, second and fractional order reactions, pseudounimolecular reactions, determination of the order, kinetics of complex reactions (limited tofirstorder):(i)Opposingreactions(ii)parallelreactionsand(iii)consecutivereactionsandtheir differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reactionrates.

Unit III: **15 Lectures**

Catalysis

Types of catalyst,specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Unit IV: **15 Lectures**

Surface chemistry

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langumuiradsorptionisotherms,surfaceareadetermination),BETtheoryofmultilayeradsorption (no derivation), Adsorption insolution.

Text Books

1. AtkinsP.W.andDePaulaJ.,*PhysicalChemistry*,*(*tenthedition)OxfordUniversityPress,2014.
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa ,2004.
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books, 2004.

Reference Books/Materials

1. Engel, T. & Reid, P. *Physical Chemistry* Third Edition, Prentice-Hall, 2012.
2. Zundhal, S.S. *Chemistry concepts and applications* Cengage India, 2011 6 Ball, D. W. *Physical Chemistry* Cengage India, 2012.

3. Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP, 2009.

4. Levine, I. N. *Physical Chemistry 6th Ed.*, Tata McGraw-Hill, 2011.
5. Metz, C. R. *Physical Chemistry 2nd Ed.*, Tata McGraw-Hill,2009.

Open Educational Resources (OER)

- Khan Academy Chemistry: https://www.khanacademy.org/science/chemistry
- MIT OpenCourseWare - Chemistry: https://ocw.mit.edu/courses/chemistry/
- Coursera - Introduction to Physical Chemistry: https://www.coursera.org/courses?query=physical%20chemistry
- ChemCollective: http://chemcollective.org/
- Chemguide: http://www.chemguide.co.uk/
- YouTube : https://www.youtube.com/playlist?list=PLB7fHrN_yPjDdR-gAPzK0lKy5Mwu5lF01
- Virtual Chemistry Experiments: http://chemcollective.org/vlab
- NOVA Labs - Chemistry: http://www.pbs.org/wgbh/nova/labs/lab/chemistry/)
- ChemSpider: http://www.chemspider.com/
- OpenStax - Chemistry: https://openstax.org/details/books/chemistry

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Assignment/P	Mid Term Examination	Attendance	End Term Examination
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course	Cours	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SCCH202 PHYSICAL CHEMISTRY-III	CO1	2	2	1	3	1	1	2	2	1	2	2	1	1	1
	CO2	2	2	1	2	1	1	1	2	1	1	1	1	1	1
	CO3	2	3	1	3	1	2	2	2	2	2	3	2	2	1
	CO4	2	3	2	3	1	2	2	2	2	2	3	2	1	2

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	Phase Equilibria
Local	-
Regional	-
National	contributing to national-level understanding of chemical processes
Global	-
Employability	-
Entrepreneurship	-
Skill Development	Developing problem-solving skills in chemical engineering
Professional Ethics	-
Gender	-
Human Values	Upholding values of scientific inquiry and knowledge.
Environment & Sustainability	-
Unit II	Chemical Kinetics
Local	-
Regional	Contributing to regional advancements in chemical kinetics and reactions.
National	-
Global	Engaging in global discussions on chemical reaction kinetics.
Employability	-
Entrepreneurship	Identifying opportunities in chemical product development and optimization.
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Catalysis
Local	Applying catalysis principles in local industries and chemical processes.
Regional	-
National	Contribution to the national-level understanding of catalysis and its applications.
Global	Engaging in global discussions on catalysis and its impact on various industries.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-

Human Values	-
Environment & Sustainability	Considering the environmental implications of catalyzed reactions.
Unit IV	Surface chemistry
Local	-
Regional	-
National	-
Global	Engaging in global discussions on surface chemistry and its significance.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	Upholding values of scientific inquiry and knowledge.
Environment & Sustainability	Considering the environmental impact of surface chemistry-related processes.
SDG	SDG 4: Quality Education;
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's Higher Education System (9.1- 9.3); .
POE/4th IR	Technical Skills that match Industry Needs/ Skill Development through project work: applications of catalysis

Teaching Plan:

Weekly Teachin	Topics / Unit No.	Textbook [TB]/ Reference Book [RB]-	Teaching-Learning
Week 1	Phase Equilibria: Concepts and Components	Atkins & DePaula (Ch. 1), Chemguide	Lecture, Discussion
Week 2	Gibbs Phase Rule and Nonreactive Systems	Atkins & DePaula (Ch. 2), Khan Academy Chemistry	Lecture, Problem-Solving
Week 3	Reactive Systems and Clausius-Clapeyron Equation	Castellan (Ch. 1, 2), ChemCollective	Lecture, Virtual Lab
Week 4	Phase Diagrams for One-Component Systems	Atkins & DePaula (Ch. 3), MIT OpenCourseWare	Lecture, Visual Aids
Week 5	Solid-Liquid Equilibria and Eutectic Points	McQuarrie & Simon (Ch. 1), NOVA Labs - Chemistry	Lecture, Interactive Activities
Week 6	Congruent and Incongruent Melting Points	McQuarrie & Simon (Ch. 2), Virtual Chemistry Experiments	Lecture, Simulation
Week 7	Solid Solutions and Three-Component Systems	Castellan (Ch. 3, 4), ChemSpider	Lecture, Case Studies
Week 8	Binary Solutions and	Atkins & DePaula (Ch.	Lecture, Videos

	Fractional Distillation	4), YouTube - Khan Academy Organic Chemistry	
Week 9	Azeotropes and Steam Distillation	McQuarrie & Simon (Ch. 3), Chemguide	Lecture, Group Work
Week 10	Nernst Distribution Law and Its Applications	Atkins & DePaula (Ch. 5), ChemCollective	Lecture, Problem-Solving, Virtual Lab
Week 11	Chemical Kinetics: Order and Molecularity	Castellan (Ch. 5), Khan Academy Chemistry	Lecture, Discussion
Week 12	Differential and Integrated Rate Laws	McQuarrie & Simon (Ch. 4), ChemSpider	Lecture, Examples, Practice Problems
Week 13	Temperature Dependence and Arrhenius Equation	Atkins & DePaula (Ch. 6), Coursera - Introduction to Physical Chemistry	Lecture, Quizzes
Week 14	Collision Theory and Absolute Reaction Rates	Castellan (Ch. 6), ChemCollective	Lecture, Interactive Activities, Revision

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes (CO)	Teaching Learning Activity	Assessment Task Methods
1	• Understand the concept of phase equilibria and its components • Apply the Gibbs Phase Rule to nonreactive and reactive systems • Analyze phase diagrams for one-	• Lecture, Visual Aids, Discussions, Examples • Problem-Solving Sessions, Virtual Labs • Case Studies, Group Work, Phase Diagram Software • Simulation,	• Quizzes, Class Participation, Assignments • Problem-Solving Assessments, Lab Reports • Presentation, Group Projects, Phase Diagram Analysis
2	• Understand the order and molecularity of reactions • Analyze differential and integrated rate laws • Explore kinetics of complex reactions • Evaluate	• Lecture, Visual Aids, Discussions, Examples • Problem-Solving Sessions, Virtual Labs • Case Studies, Group Work, Kinetics Simulation • Simulation,	• Quizzes, Class Participation, Assignments • Problem-Solving Assessments, Lab Reports • Presentation, Group Projects,

3	• Understand the types and mechanisms of catalysts • Analyze catalyzed reactions at solid surfaces • Comprehend enzyme catalysis and Michaelis-Menten mechanism	• Lecture, Visual Aids, Discussions, Examples • Problem-Solving Sessions, Virtual Labs • Case Studies, Group Work, Enzyme Kinetics Software • Simulation,	• Quizzes, Class Participation, Assignments • Problem-Solving Assessments, Lab Reports • Presentation, Group Projects,
4	• Understand physical and chemisorption processes • Analyze adsorption isotherms and surface area determination • Comprehend the BET theory of multilayer adsorption	• Lecture, Visual Aids, Discussions, Examples • Problem-Solving Sessions, Virtual Labs • Case Studies, Group Work, BET Analysis • Simulation,	• Quizzes, Class Participation, Assignments • Problem-Solving Assessments, Lab Reports • Presentation, Group Projects, BET Analysis

SCCH252	**Physical Chemistry-III Practicals**	L	T	P	C
Version 3.0		0	0	4	2
Total Contact Hours	**30**				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

Course Objectives

1. To be able to calibrate and take measurements on a conductometer and a potentiometer.
2. To learn to perform acid-base and redox titrations.
3. To find out dissociation constant of a weak acid.
4. To calculate the values of cell constant, equivalent conductance from the conductance measurements.

Course Outcomes

On completion of this course, the students will be able to

CO1: recall and understand the fundamental concepts and principles of conductometry and potentiometry.

CO2: apply the acquired knowledge to perform calculations and analyse experimental data in conductometry and potentiometry.

CO3: design and conduct experiments, interpret results, and evaluate the accuracy and precision of the obtained data in conductometry and potentiometry.

CO4: solve complex problems related to conductometry and potentiometry and critically analyze experimental limitations and sources of error.

Catalog Description

This course imparts the basic knowledge of conductometry and potentiometry, and how these measurements can be used to calculate various parameters. This course enables the students to perform several types of acid-base titrations, and redox titrations. It also discusses the calculations of cell constant, equivalent constant, and degree of dissociation for conductance measurements.

Course Content

List of Experiments

Conductometry

1.Determination of cell constant

2.Equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

3.Conductometry titrations of: Strong acid Vs. strong base (ii) Weak acid vs. strong base, (iii) Mixture of strong acid and (iv)weak acid vs. strong base, Strong acid vs. weak base.

Potentiometry

Potentiometric titrations of: (i) Strong acid vs. strong base (ii) Weak acid vs. strong base

(iii) Dibasic acid vs. strong base (iv) Potassium dichromate vs. Mohr's salt.

3. To study kinetically the reaction rate of decomposition of iodide by H_2O_2.

4. Determination of surface tension/percentage composition of given organic mixture usingsurface tension method.

5. Determination of viscosity/percentage composition of given organic mixture usingviscosity method.

Recommend books/References:

1.Khosla,B.D.;Garg,V.C.andGulati,A.*SeniorPracticalPhysicalChemistry*,R.Chand New Delhi,2011.
2.Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry* Eighth Edition*;* McGraw-Hill: New York,2003.
3.Halpern,A.M.andMcBane,G.C.*ExperimentalPhysicalChemistry3rdEd.;*W.H.Freeman& Co.: New York,2003.

Open Educational Resources (OER)

- MIT Open Courseware - Principles of Chemical Science: https://ocw.mit.edu/courses/chemistry/5-111-principles-of-chemical-science-fall-2014/
- Khan Academy - Acid-Base Equilibrium: https://www.khanacademy.org/science/chemistry/acids-and-bases-topic
- Coursera - Analytical Chemistry by Rice University: https://www.coursera.org/learn/analytical-chemistry
- ChemCollective - Virtual Chemistry Experiments: http://chemcollective.org/vlab
- PhET Interactive Simulations - Acid-Base Solutions: https://phet.colorado.edu/sims/html/acid-base-solutions/latest/acid-base-solutions_en.html
- National Repository of Open Educational Resources (NROER) - Chemistry: https://nroer.gov.in/#!/explore/subject/chemistry
- Chemguide - Acid-Base Equilibria: http://www.chemguide.co.uk/physical/equilibria/acidsbaseeqia.html
- ChemCollective - Acid-Base Titration Simulations: http://chemcollective.org/acid-base-titration
- OpenStax Chemistry Textbook: https://openstax.org/details/books/chemistry
- Wikibooks - Analytical Chemistry: https://en.wikibooks.org/wiki/Analytical_Chemistry

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Compon	**Conduct of**	**Lab Record/Quizzes/**	**Attendanc**	**End Term**
Weight	**20**	**20**	**10**	**50**

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Course Code and Title	**Course Outcome (CO)**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
SCCH252 PHYSICAL CHEMISTRY-III PRACTICALS	**CO1**	**3**	**2**	**2**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**2**	**1**
	CO2	**2**	**3**	**2**	**3**	**1**	**2**	**1**	**3**	**2**	**2**	**2**	**2**	**3**	**2**
	CO3	**1**	**3**	**1**	**2**	**2**	**3**	**2**	**3**	**2**	**3**	**1**	**1**	**3**	**2**
	CO4	**2**	**3**	**2**	**3**	**1**	**3**	**2**	**3**	**2**	**3**	**2**	**2**	**3**	**3**

1 = Lightly Mapped

2 = Moderately Mapped

3 = Strongly Mapped

Unit I	Conductometry; 1.Determination of cell constant 2. Equivalent conductance, degree of dissociation and dissociation constant of a weak acid. 3.Conductometric titrations of: Strong acid Vs. strong base (ii) Weak acid vs. strong base, (iii) Mixture of Strong acid and (iv) weak acid vs. strong base, Strong acid vs. weak base. Potentiometry Potentiometric titrations of: (i) Strong acid vs. strong base (ii) Weak acid vs. strong base (iii) Dibasic acid vs. strong base (iv) Potassium dichromate vs. Mohr's salt.
Local	-
Regional	-
National	-
Global	This course imparts the basic knowledge of conductometry and potentiometry, and how these measurements can be used to calculate various parameters. This course enables the students to perform several types of acid-base titrations, and redox titrations. It also discusses the calculations of cell constant, equivalent constant, and degree of dissociation for conductance measurements.
Employability	-
Entrepreneurship	-
Skill Development	This course imparts the basic knowledge of conductometry and potentiometry, and how these measurements can be used to calculate various parameters. This course enables the students to perform several types of acid-base titrations, and redox titrations. It also discusses the calculations of cell constant, equivalent constant, and degree of dissociation for conductance measurements.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	This course covers some simple methods for determination water quality parameter like COD, BOD, and DO, major ions present in soil and aerated drinks.
SDG	(SDG 4- 4.4, 4.3)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3), Promoting High Quality research (18.1-18.9); Technology Use and Integration (23.1-23.13)
POE/4th IR	Global Education Knowledge, Technical Skill that match Industry Needs, Focus on Emloyability Skills (Regional/ Global), Internship Program, On Campus Job

Teaching Plan:

Weekly Teaching	Topic/Unit No.	Textbook [TB]/	Teaching-Learning Methods
Week1	Introduction to Conductometry and Potentiometry	Khosla et al., Garland et al., Halpern and McBane	Lecture, Discussion
Week 2	Determination of Cell Constant	Khosla et al., ChemCollective	Lab Demonstration, Experiment
Week 3	Equivalent Conductance	Khosla et al., Chemguide	Lecture, Problem-Solving
Week 4	Degree of Dissociation and Dissociation Constant	Khosla et al., Khan Academy	Lecture, Discussion
Week 5	Conductometric Titrations (Strong Acid vs. Strong Base)	Garland et al., ChemCollective	Lab Demonstration, Experiment
Week 6	Conductometric Titrations (Weak Acid vs. Strong Base)	Garland et al., ChemCollective	Lab Demonstration, Experiment
Week 7	Conductometric Titrations (Mixture of Strong Acid)	Garland et al., ChemCollective	Lab Demonstration, Experiment
Week 8	Conductometric Titrations (Weak Acid vs. Strong Base)	Garland et al., ChemCollective	Lab Demonstration, Experiment
Week 9	Potentiometric Titrations (Strong Acid vs. Strong Base)	Garland et al., PhET Interactive Simulations	Lab Demonstration, Experiment
Week 10	Potentiometric Titrations (Weak Acid vs. Strong Base)	Garland et al., PhET Interactive Simulations	Lab Demonstration, Experiment
Week 11	Potentiometric Titrations (Dibasic Acid vs. Strong Base)	Garland et al., PhET Interactive Simulations	Lab Demonstration, Experiment
Week 12	Potentiometric Titrations (Potassium Dichromate vs. Mohr's Salt)	Garland et al., PhET Interactive Simulations	Lab Demonstration, Experiment
Week 13	Applications of Conductometry and Potentiometry	Khosla et al., NROER	Lecture, Discussion
Week 14	Review and Revision	Khosla et al., Chemguide	Recap, Problem-Solving, Review

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning Outcomes (CLOs)	Teaching-Learning Activities (TLAs)	Assessment Task Method
1	• Understand the principles of conductometry and potentiometry. • Explain the concept of equivalent conductance and degree of dissociation. • Perform	• Lectures on conductometry and potentiometry principles and instrumentation techniques. • Interactive discussions and problem-solving sessions in the classroom. • Laboratory demonstrations and hands-on	• Written tests • Class participation • Laboratory reports • Virtual
2	• Analyze experimental data from conductometric titrations. • Evaluate the accuracy and precision of experimental results.	• Group work and data analysis of conductometric titration curves. • Critical evaluation of experimental limitations and sources of error.	• Data exercises • Critical interpretation analysis of reports
3	• Demonstrate an interdisciplinary approach in chemical analysis. • Utilize digital resources for conducting research and data analysis.	• Incorporate case studies and real-life applications of conductometry and potentiometry. • Online research for advanced scientific knowledge and emerging trends in the field.	• Case study presentations • Research paper assignments
4	• Develop critical and innovative thinking skills in problem-solving. • Enhance communication skills for presenting analytical findings. • Apply ethical considerations in chemical research and analysis. • Demonstrate capability in handling professional responsibilities	• Problem-solving workshops and group discussions on complex analytical scenarios. • Presentations on analytical results and their implications. • Discussions on ethical practices in chemical analysis and digital literacy. • Role-playing and scenarios related to professional conduct in a laboratory setting	• Problem -solving assessments • Presentation assessments • Ethical case study assessments • Professional conduct evaluations

COURSE OBJECTIVES

The course will enable the student-teacher to:

- To learn the students about oxidation- reduction and metallurgical processes
- To learn the student structure, properties and uses of s and p-block elements
- To study about the shapes and uses of noble gas compounds
- To enable the students to gain detailed idea about B, Si, P based inorganic polymers

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Acquaint with general concept of oxidation and reduction.
CO2: Provide information of purification of metals by different metallurgical processes.
CO3: Emphasize on chemical properties of s and p-block elements.
CO4: Understanding about the structure and uses of compounds from s and p-block elements.
CO5: Learn the compounds of noble gases and structures on the basis of VSEPR and MO theory.

SCCH204	**Inorganic Chemistry - II**	**L**	**T**	**P**	**C**
Version 3.0		**3**	**1**	**0**	**4**
Total Contact Hours	**60**				
Pre-requisites/Exposure	**Basics of Chemistry**				
Co-requisites	**--**				

CO6: Learn about the preparation of inorganic compounds.
CO7: Learn about the structural aspects of inorganic polymers and their applications.

CATALOG DESCRIPTION

In this course students learn about the oxidation-reduction reactions and the metallurgical process for the purification of metals. Students will learn some basic concepts of inorganic chemistry and the structure, properties, uses of compounds of s and p-block elements. The course will provide basics of noble gases, preparation and properties of some noble gases compounds. The students will also get an idea about structure and applications of various inorganic polymers based on silicon, boron and phosphorus.

COURSE CONTENT

Unit I: **15Lecture**

Oxidation-Reduction and general principle of metallurgy

Redox equations, Standard Electrode Potential and its application to inorganic reactions.Occurrenceofmetalsbasedonstandardelectrodepotentials.Ellinghamdiagramsforreductionof metal oxides using carbon or carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel- de Boer process and Mond’s process, Zonerefining.

Unit II: **15Lecture**

Chemistry of *s* and *p* Block Elements

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation.Complex formation tendency of *s* and *p* block elements.Hydrides and their classification ionic, covalent and interstitial.Basic beryllium acetate and nitrate. Structure, bonding, preparation, properties and uses.Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine.Per-oxo acids of Sulphur inter-halogen compounds, poly- halide ions, pseudo-halogens, properties of halogens.

Unit III: **15Lecture**

Noble Gases

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF2, XeF4 and XeF6; Bonding in noble gas compounds (Valence bond and MO treatment for XeF2), Shapes of noble gas compounds (VSEPR theory).

Unit IV: **15Lecture**

Types of inorganic polymers,Comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes.Borazines, silicates and phosphazenes, and polysulphates.

Text Books:

Lee, J. D. Concise Inorganic Chemistry, Wiley, 5th Edn

Reference Books:

1. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
2. Greenwood, N.N., Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
3. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
4. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
5. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry Fourth Ed., Pearson, 2010
6. Atkins, P. W and Shriver D. N. Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).

Open Educational Resources (OER)

- (12) Oxidation and Reduction Reactions (Part 1) - Chemical Reactions and Equations | Class 10 Chemistry - YouTube
- (12) Ch.1st General principles of metallurgy of #B.Sc 4th semester of Inorganic Chemistry proper notes - YouTube
- (12) Metallurgy | bsc 2nd yr Chemistry | Aarti mam Chemistry | Physics guru |inorganic Chemistry - YouTube
- (12) I L 1 I S Block Elements I Electronic configuration I Atomic Radii - YouTube

- [(12) BSc first year inorganic chemistry : Main points And General properties of p-block elements #RVCc - YouTube]
- beta.chem.uw.edu.pl/people/WGrochala/NG_chemistry.pdf
- UNIT-II-Polymers.pdf (aits-tpt.edu.in)
- https://faratarjome.ir/u/media/shopping_files/store-EN-1429082956-7175.pdf

Assessment & Evaluation

Components	Quiz/Assignment/ Presentation	Mid Term Examination	Attendance	End Term Examination
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course Code and Title	Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2	PSO 3	PSO 4
SCCH204 Inorganic Chemistry - II	CO1	3		2		3						3			
	CO2		3	3										3	
	CO3	3											3		
	CO4	2										2			
	CO5				3							2			
	CO6			2		2						2			
	CO7		3									2			

Unit I	Oxidation-Reduction and general principle of metallurgy
Local	Understanding local metallurgical processes and their applications.
Regional	Applying metallurgical principles to regional mining and extraction industries.
National	Contributing to national-level understanding of metallurgy and metal extraction.
Global	Engaging in global discussions on metallurgical processes and resource utilization.
Employability	Building foundational knowledge for careers in metallurgy and mining.

Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Considering the environmental impact of metallurgy.
Unit II	Chemistry of *s* and *p* Block Elements
Local	Local industries may apply principles of block elements in various chemical processes.
Regional	-
National	Contribution to the national-level understanding of block elements.
Global	-
Employability	-
Entrepreneurship	Identifying opportunities for developing new materials and chemicals.
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Noble Gases
Local	-
Regional	Regional industries can benefit from understanding noble gas applications.
National	-
Global	-
Employability	Building knowledge and skills for careers in gas-related industries.
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Inorganic Polymers
Local	-
Regional	-
National	Contribution to the national-level understanding of inorganic polymers.
Global	Engaging in global discussions on inorganic polymers and their properties.

Employability	Building knowledge and skills for careers in polymer-related industries.
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	(4.4) (SDG 4.7)
NEP	India's Higher Education System (9.1- 9.3)
POE/4th IR	Construction of new knowledge related to electronegativity and the overlap of atomic orbitals

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education	Teaching-Learning Method
Week 1	**Unit 1:** Redox equations, Standard Electrode Potential and its application to inorganic reactions	**TB-1/ RB-3/ OER-1**	Group Discussion/Presentation
Week 2	**Unit 1:** Ellingham diagrams for reduction of metal oxides using carbon or carbon monoxide	**TB-1/ RB-3/ OER-1**	Group Discussion/Presentation
Week 3	**Unit 1:** Hydrometallurgy. Methods of purification of metals: Electrolytic	**TB-1/ RB-3/ OER-2/3**	Group Discussion/Presentation
Week 4	**Unit 2:** Inert pair effect, Relative stability of different oxidation states, diagonal relationship	**TB-1/ RB-3/ OER-4**	Group Discussion/Presentation
Week 5	**Unit 2:** Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and	**TB-1/ RB-3/OER-5**	Group Discussion/Presentation

Week 6	**Unit 2:** Structure, bonding, preparation, properties and uses. Boric acid and borates, boron	**TB-1/ RB-3/OER-5**	Group Discussion/Presentation
Week 7	**Unit 2:** silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Per-oxo	**TB-1/ RB-3/OER-5**	Group Discussion/Presentation
Week 8	**Unit 3:** Occurrence and uses, rationalization of inertness of noble gases, Clathrates;	**TB-1/ RB-3/OER-6**	Group Discussion/Presentation
Week 9	**Unit 3: P**reparation and properties of XeF2, XeF4 and XeF6; Bonding in noble gas compounds	**TB-1/ RB-3/OER-6**	Group Discussion/Presentation
Week 10	**Unit 3:** Valence bond and MO treatment for XeF2, Shapes of noble gas compounds (VSEPR	**TB-1/ RB-3/OER-6**	Group Discussion/Presentation
Week 11	**Unit 4:** Types of inorganic polymers, comparison with organic polymers,	**TB-1/ RB-3/OER-7**	Group Discussion/Presentation
Week 12	**Unit 4:**synthesis, structural aspects and applications of silicones and siloxanes. Borazines,	**TB-1/ RB-3/OER-8**	Group Discussion/Presentation
Week 13	**Unit 4:** silicates and phosphazenes, and polysulphates.	**TB-1/ RB-3/OER-8**	Group Discussion/Presentation
Week 14	**Revision**	**TB-1/RB-3**	Group Discussion/Presentation

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning	Teaching	Assessment

1	A comprehensive understanding of oxidation and reduction processes, as well as the principles and practices of metallurgy.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-

SCCH254	**Inorganic Chemistry – II Practicals**	**L**	**T**	**P**	**C**
Version 3.0		**0**	**0**	**4**	**2**
Total Contact Hours	**30**				

2	Grasp the periodic trends and variations in the properties of s-block and p-block elements, including atomic and ionic radii, electronegativity, ionization energy, and electron affinity. Understand the		
3	A comprehensive understanding of noble gases and their unique properties, applications, and significance in various fields of science and technology.		
4	Understanding of polymers, their synthesis, properties, and applications.		

Pre-requisites/Exposure	Inorganic preparation and iodometric analysis
Co-requisites	--

COURSE OBJECTIVES

- To familiarize the students with quantitative analysis by iodometric and iodimetric titrations.
- To expertise the students for inorganic salt preparation and use of analytical apparatus.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1. Learn the Quantitative analysis of unknown inorganic compounds.
CO2. Study iodometric and iodimetric analysis.
CO3. Learn about inorganic salt preparation
CO4. Learn to perform inorganic experiments with various instruments

CATALOG DESCRIPTION

This course helps to gain knowledge of quantitative analysis by iodometric and iodimetric titrations for the estimation. This course engages the students for simple inorganic salt preparation by using appropriate analytical method and handling of instruments. Students also get idea of using special apparatus and techniques for the synthesis.

COURSE CONTENT

A. **Iodo / Iodimetric Titrations**

i. Estimation of Cu (II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
ii. Estimation of (i) arsenite and (ii) antimony iodimetrically
iii. Estimation of available chlorine in bleaching powder iodometrically.

Inorganic preparations

I. Cuprous Chloride, Cu_2Cl_2
II. Preparation of Aluminium potassium sulphate (Potash alum) or Chromealum.
i. (Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Text Books:

Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* Sixth Edition, Pearson,2009.

Reference Books/Materials

1. O. P. Pandey, D.N. Bajpai, S.Giri, Practical chemistry, S. Chand & Company Pvt. Ltd.
2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

Open Educational Resources (OER)

- (12) Iodometric Estimation of Copper using Sodium thiosulphate - YouTube
- THE DETERMINATION OF ARSENIC WITH IODINE (noctrl.edu)
- UNIT IV Redox titrations Priciple and Applications (wordpress.com)
- (12) iodimetry titration || Titration of iodine with sodium thiosulphate - YouTube

- (12) Preparation of cuprous chloride (CuCl) from cupric sulphate - YouTube
- (12) Formation of Potash Alum Experiment 2 inorganic chemistry - YouTube
- (12) practical-chrome alum - YouTube

Assessment & Evaluation

Components	**Conduct of Experiment**	**Lab Record/Quizzes/ Viva-Voce**	**Attendance**	**End Term Practical Examination**
Weightage (%)	**20**	**20**	**10**	**50**

Programme and Course Mapping

Course Code and Title	**Course Outcome**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
SCCH254 Inorganic Chemistry – II Practicals	**CO1**	3										3		3	
	CO2	3										3		3	
	CO3		3									3	3		
	CO4				3							3	3		

Unit 1	(A)Iodo / Iodimetric Titrations (i)Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically). (ii)Estimation of (i) arsenite and (ii) antimony iodimetrically (iii)Estimation of available chlorine in bleaching powder iodometrically. (B)Inorganic preparations (i)Cuprous Chloride, Cu_2Cl_2 (ii)Preparation of Aluminium potassium sulphate (Potash alum) or Chrome alum.
Local	-
Regional	-
National	-
Global	Iodo / Iodimetric Titrations, Inorganic preparations

Employability	-
Entrepreneurship	-
Skill Development	Students will learn the hand on experience of simple inorganic salt preparation by using appropriate analytical method and handling of instruments. Students also get idea of using special apparatus and techniques for the synthesis.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	(4.4) SDG 4.7)
NEP	India's Higher Education System (9.1- 9.3)
POE/4th IR	-

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education	Teaching-Learning Method
Week 1	Estimation of Cu (II) and $K_2Cr_2O_7$ using sodium thiosulphate solution	TB-1/OER-1	Discussion and Experiment
Week 2	Estimation of (i) arsenite and (ii) antimony iodimetrically	TB-1/OER-2/3	Discussion and Experiment
Week 3	Estimation of available chlorine in bleaching powder iodometrically.	TB-1/OER-3/4	Discussion and Experiment
Week 4	Cuprous Chloride, Cu_2Cl_2	TB-1/OER-5	Discussion and Experiment
Week 5	Preparation of Aluminium potassium sulphate (Potash alum)	TB-1/OER-6	Discussion and Experiment
Week 6	Preparation of Chromealum.	TB-1/OER-7	Discussion and Experiment
Week 7	Revision		Discussion and Experiment
Week 8	Revision		Discussion and Experiment
Week 9	Revision		Discussion and Experiment
Week 10	Revision		Discussion and Experiment

Week 11	Revision		Discussion and Experiment
Week 12	Revision		Discussion and Experiment
Week 13	Revision		Discussion and Experiment
Week 14	Revision		Discussion and Experiment

Facilitating the Achievement of Course Learning Outcomes

EC009	Open Sourceware in GIS and Remote Sensing	L	T	P	C
Version 3.0		2	0	0	2
Total Contact Hours	30				
Pre-requisites/Exposure	Basics of Remote Sensing, Geographical Information System (GIS)				
Co-requisites	--				

COURSE OBJECTIVES

1. Introduce students to open-source software in the field of Geographic Information Systems (GIS) and Remote Sensing.
2. Familiarize students with the fundamental concepts and principles of GIS and remote sensing.
3. Provide hands-on experience with open-source software tools commonly used in GIS and remote sensing.
4. Develop practical skills in data acquisition, processing, analysis, and visualization using open-source software.
5. Enable students to apply open-source GIS and remote sensing tools in real-world scenarios and projects.
6. Promote critical thinking and problem-solving abilities in utilizing open-source software for geospatial analysis and interpretation.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Understand the fundamentals of GIS and remote sensing and their applications in various domains.

CO2: Perform spatial analysis operations, including data overlay, buffering, and proximity analysis, using open-source software.

CO3: Apply image processing techniques to remote sensing data using open-source tools like R and Python.

CO4: Integrate GIS and remote sensing data, analyze spatial patterns, and derive meaningful insights.

CO5: Visualize geospatial data and create high-quality maps using open-source software.

CO6: Apply open-source GIS and remote sensing tools in practical projects related to environmental management, urban planning, or natural resource assessment.

CATALOG DESCRIPTION

The course " OPEN SOURCEWARE IN GIS AND REMOTE SENSING:" provides students with a comprehensive understanding of remote sensing principles, techniques, and its integration with

Geographic Information Systems (GIS). Students will learn how to acquire, process, analyze, and interpret remote sensing data for various applications, including environmental monitoring, natural resource management, and urban planning. The course covers both theoretical foundations and practical skills required to work with remote sensing and GIS technology.

COURSE CONTENT

Unit I:

14 Lecture

REMOTE SENSING: Remote Sensing – history & development, definition, concept and principles, Basic principles of electromagnetic radiation and sensor characteristics, Energy Resources, radiation principles, EM Radiation and EM Spectrum, Black body radiation, Laws of radiation, Interaction of EMR with atmosphere and Earth's surface, limitation of Remote sensing, Ideal and Real Remote sensing. Advantages and application of of Remote sensing.

UNIT II **12 Lecture**

GEOGRAPHIC INFORMATION SYSTEM: Overview of GIS technology and its applications, Basic principles and components of GIS, Introduction to GIS software and data formats, Data collection techniques (GPS, remote sensing, surveys), Data quality and accuracy considerations, Introduction to remote sensing and its relationship with GIS, Applications of GIS, Integration of remote sensing data with GIS for analysis and mapping

Text Books:

- Hans van der K., & Kurt M. QGIS for Hydrological Applications: Recipes for Catchment Hydrology and Water Management
- Gupta, R.P.., 1990: Remote Sensing Geology. Springer Verlag
- Lillesand, T.M., and Kieffer, R.M., 1987: Remote Sensing and Image Interpretation, John Wiley.

Open Educational Resources (OER)

- https://www.bbau.ac.in/dept/Physics/TM/Env%20Physics_PHM400_DoP_2.pdf
- https://egyankosh.ac.in/bitstream/123456789/39528/1/Unit-1.pdf
- https://www.heavy.ai/technical-glossary/remote-sensing
- https://www.highpointnc.gov/DocumentCenter/View/1900/What-is-GIS-PDF?bidId=#:~:text=A%20working%20GIS%20integrates%20five,data%2C%20people%2C%20and%20methods.&text=Hardware%20is%20the%20computer%20on,stand%2Dalone%20or%20networked%20configurations.
- https://www.uou.ac.in/sites/default/files/slm/GIS-503.pdf

Assessment & Evaluation

Components	**Assignment**	**Mid Term Examination**	**Attendance**	**End Term Examination**

Weightage (%)	**20**	**20**	**10**	**50**

Programme and Course Mapping

Course Code and Title	Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO1	PSO2	PSO3	PSO4
SEC009 Open Sourceware in GIS and Remote Sensing	**CO1**														
	CO2		**3**												
	CO3								**3**						
	CO4									**3**					
	CO5									**3**					
	CO6		**3**												

1=weakly mapped

2= moderately mapped

3=strongly mapped

Unit I	REMOTE SENSING
Local	Understanding local applications for remote sensing in urban planning, agriculture, and more.
Regional	-
National	Contribution to the national-level understanding of remote sensing technology and its benefits
Global	-
Employability	Building foundational knowledge for careers in remote sensing and geospatial analysis.
Entrepreneurship	Student centric methods, such as experiential learning, participative learning and problem-solving methodologies (2.3.1)

Skill Development	Developing expertise in remote sensing technology and data analysis.
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	GEOGRAPHIC INFORMATION SYSTEM
Local	Local governments and organizations can use GIS for urban planning, infrastructure development, etc.
Regional	-
National	Contributing to the national-level understanding of GIS and its applications.
Global	Engaging in global discussions on GIS technology and its role in data analysis and management.
Employability	-
Entrepreneurship	Identifying opportunities in the GIS industry and geospatial data analysis.
Skill Development	Developing expertise in GIS data integration and analysis.
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	Upholding values of responsible data use and information sharing.
Environment & Sustainability	-
SDG	Skill for Decent Work; Sustainable Development and Global Citizenship
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Global Education Knowledge, imagination/creativity, assumption of responsibility and for making decisions, planning, coordinating and organising ability

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/	Teaching-Learning Method
Week 1	**Unit 1:** Remote Sensing – history & development.	**TB-2/ OER-3**	Group Discussion/Presentation
Week 2	**Unit 1:** Basic principles of electromagnetic	**TB-2/ OER-1/2**	Group Discussion/Presentation

Week 3	**Unit 1:** Interaction of EMR with atmosphere and	**TB-2/ OER-3**	Group Discussion/Presentation
Week 4	**Unit 2:** Overview of GIS technology and its applications. Basic	**TB-2/ OER-4**	Group Discussion/Presentation
Week 5	**Unit 2:** Introduction to GIS software and data formats. Data	**TB-2/ OER-4**	Group Discussion/Presentation
Week 6	**Unit 2:** Data quality and accuracy considerations.	**TB-2/ OER-5**	Group Discussion/Presentation
Week 7	**Unit 2:** Applications of GIS, Integration of remote sensing data	**TB-2/ OER-5**	Group Discussion/Presentation
Week 8	**Revision**		Group Discussion/Presentation
Week 9	**Revision**		Group Discussion/Presentation
Week 10	**Revision**		Group Discussion/Presentation
Week 11	**Revision**		Group Discussion/Presentation
Week 12	**Revision**		Group Discussion/Presentation
Week 13	**Revision**		Group Discussion/Presentation
Week 14	**Revision**		Group Discussion/Presentation

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning	Teaching Learning	Assessment

1	Explain the principles and advantages of using open source software in GIS and remote sensing.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Demonstrate proficiency in using open source GIS software (e.g., QGIS, GRASS GIS) for data		
3	Analyze real-world spatial problems and apply open source software tools to develop solutions.		
4	Organize and maintain spatial databases using open source tools.		

SEMESTER V

SCCH 301	**Inorganic Chemistry - III**	**L**	**T**	**P**	**C**
Version 3.0		**3**	**1**	**0**	**4**
Total contact hours	60				
Pre-requisites/Exposure	Basics of transition elements and inner transition elements				
Co-requisites	--				

Course Objectives

1. In order to study transition metals to understand the trends in properties and reactivity of the d-block elements
2. To explain the typical physical and chemical properties of the transition metals.

3. Describe the role of metal ions that are involved in electron-transfer reactions in biological systems.
4. To be able to name coordination compounds and to be able to draw the structure based on it's name.

Course Outcomes

On completion of this course, the students will be able to

CO1. Understand the coordination numbers and geometric shapes of the complexes.

CO2. To acquire knowledge of physical and chemical composition of the transition elements complexes.

CO3. Identify the main toxicological mechanisms of metals and the biological defenses against the toxic effects.

CO4. Apply the basic principles in inorganic and general chemistry to interdisciplinary topics in the field of bioinorganic chemistry.

CO5. The students will be able to explain the fundamental concepts in coordination chemistry of transition metals.

CO6. Know the chemistry of the Lanthanides and the Actinides.

Catalog Description

This course gives an introduction to coordination chemistry and an overview of important theories like crystal field theory, molecular orbital theory and their range of application within detection of structure of coordination compounds. Important magnetic and electrical properties of transition and inner transition elements are reviewed. The present course also includes main toxicological mechanisms of metals and the biological defenses against the toxic effects.

Course Content

UNIT I **18 Lecture**

Coordination Chemistry

Werner's theory, EAN rule, piano-stool compounds, valence bond theory (inner and outer orbital complexes), Crystal field theory, d-orbital splitting, , weak and strong fields, pairing energies, factors affecting the magnitude of (Δ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar complexes, d orbital splitting in trigonal bipyramidal, square pyramidal and cubic ligand field environments, CFSE, Variation of lattice energies, enthalpies of hydration and crystal radii variations in halides of first andsecondrowtransitionmetalseries,QualitativeaspectofLigandfieldtheory,MOdiagramsof representative coronation complexes, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination number 4 and 6, Chelateeffect,

UNIT II **12 Lecture**

Transition Elements

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams).Difference between the first, second and third transitionseries.ChemistryofTi,V,Cr, Mn,FeandCoinvariousoxidationstates(excludingtheir metallurgy)

UNIT III
12 Lecture
Lanthanoids and Actinides

Electronic configuration, oxidation states, color, spectra and magnetic behavior, lanthanide contraction, separation of lanthanides (ion-exchange method only).

UNIT IV **18 Lecture**
Bioinorganic Chemistry

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on distribution of metals.Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), toxicity, chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

Recommended text books/References:

1. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
2. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
3. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
4. Basolo,F,andPearson,R.C.*MechanismsofInorganicChemistry*,JohnWiley&Sons,NY,1967. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann,1997.

Open Educational Resources (OER)

- https://www.youtube.com/watch?v=kgiyurcr5XI&list=PLdZcCa6mtW22HTEHF8-rqOyXD-fNB7OKD
- http://www.vpscience.org/materials/Unit%203%20B%20Coordination%20chemistry.pdf
- https://www.hcpgcollege.edu.in/sites/default/files/B.SC-II%20COORDINATION%20COMPOUNDS%20%28BY%20DR.%20RAKESH%20MANI%20MISHRA%29.pdf
- TRANSITION ELEMENTS (B.SC-II) INORGANIC CHEMISTRY PAPER-I.pdf (hcpgcollege.edu.in)
- https://www.arsdcollege.ac.in/wp-content/uploads/2020/03/chemistry-of-3d-metal-notes_compressed.pdf
- https://www.youtube.com/watch?v=MLOAmSprzrQ&pp=ygUZTGFudGhhbm9pZHMgYW5kIEFjdGluaWRlcw%3D%3D

- Bioinorganic Chemistry (1).pdf (shivajicollege.ac.in)
- https://www.youtube.com/watch?v=SFa52CM30Ic&list=PLzx4lccVfC6dmrEdNFui7XTLh9Yctd8RC
- http://homes.nano.aau.dk/fp/uke/pdf/Bio%20Inorganic%20Chemistry.pdf

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Components	**Quiz/Assignment/**	**Mid Term**	**Attendanc**	**End Term**
Weightage (%)	**20**	**20**	**10**	**50**

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Course Code and Title	**Course Outcome**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
SCCH 301 Inorganic Chemistry - III	**CO1**	3								2					
	CO2			3								3		2	
	CO3	3			3										
	CO4											3			
	CO5	3	2										2		
	CO6								2						3

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	Coordination Chemistry

Local	Local chemical industries may apply coordination chemistry principles in materials and catalysts.
Regional	-
National	Contributing to national-level understanding of coordination chemistry and its applications.
Global	Engaging in global discussions on coordination chemistry principles and their applications.
Employability	-
Entrepreneurship	Identifying opportunities in the chemical industry, materials science, and catalysis.
Skill Development	Developing expertise in coordination chemistry, ligand field theory, and MO theory.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	Transition Elements
Local	-
Regional	Regional materials science and catalysis industries can benefit from transition elements knowledge.
National	-
Global	Engaging in global discussions on the role of transition elements in chemistry and industry.
Employability	-
Entrepreneurship	Identifying opportunities in the chemical industry, catalysis, and materials development.
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Considering the environmental impact of transition element applications.
Unit III	Lanthanides and Actinides
Local	-
Regional	-
National	Contribution to the national-level understanding of lanthanides, actinides, and their properties.
Global	Engaging in global discussions on lanthanides, actinides, and their applications.

Employability	Building knowledge and skills for careers involving lanthanides, actinides, and materials.
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Bioinorganic Chemistry
Local	Local research and industries may use Bioinorganic Chemistry in materials and applications.
Regional	Regional healthcare, biotechnology, and environmental sectors can benefit from this knowledge.
National	Contributing to the national understanding of bioinorganic chemistry, health, and the environment.
Global	Engaging in global discussions on bioinorganic chemistry's role in health and the environment.
Employability	Building foundational knowledge for careers in healthcare, biotechnology, and environmental sectors.
Entrepreneurship	Identifying opportunities in healthcare, biotechnology, and environmental sectors.
Skill Development	-
Professional Ethics	Promoting ethical practices in healthcare, biotechnology, and environmental research.
Gender	-
Human Values	-
Environment & Sustainability	Considering the environmental impact of metal ions and bioinorganic processes.
SDG	Scholarships for Higher Education 4b,
NEP	Quality (9.1- 9.3)(9.1.1)
POE/4th IR	Effective and sustainable learning required for employability/Learning of structure of compounds with basic concepts which helps them in higher education and research

Teaching Plan:

Weekly Teaching Pl...	Topic/Unit No.	Textbook [TB]/ Ref...	Teaching-Learning Method

Week 1	**Unit 1:** Werner's theory, EAN rule, piano-stool compounds, valence bond theory (inner and outer orbital complexes), Crystal field theory, d-orbital splitting	**TB-1/ RB-3/ OER-1/2**	Group Discussion/Presentation
Week 2	**Unit 1:** weak and strong fields, pairing energies, factors affecting the magnitude of (Δ). Octahedral vs. tetrahedral coordination, tetragonal distortions from	**TB-1/ RB-1/ OER-2**	Group Discussion/Presentation
Week 3	**Unit 1:** square planar complexes, d orbital splitting in trigonal bipyramidal, square pyramidal and cubic ligand field environments, CFSE	**TB-1/ RB-3/ OER-1/2**	Group Discussion/Presentation
Week 4	**Unit 1:** Variation of lattice energies, enthalpies of hydration and crystal radii variations in halides of first and second row transition	**TB-1/ RB-1/ OER-3**	Group Discussion/Presentation
Week 5	**Unit 1:**Isomerism in coordination compounds. Stereochemistry of complexes with the coordination number 4 and 6, Chelate effect	**TB-1/ RB-1/OER-3/4**	Group Discussion/Presentation
Week 6	**Unit 2:** General group trends with special reference to electronic configuration, colour, variable valency	**TB-1/ RB-1/OER-3/4**	Group Discussion/Presentation
Week 7	**Unit 2:** Magnetic and catalytic properties, and ability to form complexes.	**TB-1/ RB-3/OER-4**	Group Discussion/Presentation
Week 8	**Unit 2:** Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third	**TB-1/ RB-1/OER-4/5**	Group Discussion/Presentation
Week 9	**Unit 2:** Chemistry of Ti,V,Cr, Mn,Fe and Co in various oxidation states (excluding their metallurgy)	**TB-1/ RB-3/OER-4**	Group Discussion/Presentation

Week 10	**Unit 3:** Electronic configuration, oxidation states, color, spectra and magnetic behavior	**TB-1/ RB-1/OER-5/6**	Group Discussion/Presentation
Week 11	**Unit 3:** Lanthanide contraction, separation of lanthanides (ion-exchange method only).	**TB-1/ RB-4/OER-5/6**	Group Discussion/Presentation
Week 12	**Unit 4:** Metal ions present in biological systems, classification of elements according to their action in biological system	**TB-1/ RB-2/OER-7/8**	Group Discussion/Presentation
Week 13	**Unit 4:** Geochemical effect on distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals	**TB-1/ RB-2/OER-7**	Group Discussion/Presentation
Week 14	**Unit 4:** Toxicity of metal ions (Hg, Pb, Cd and As), toxicity, chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin;	**TB-1/ RB-2/OER-8/9**	Group Discussion/Presentation
Week 15	**Revision**	**TB-1/RB-3**	Group Discussion/Presentation

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Describe the coordination compounds and different theories with examples, nomenclature etc.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Expalin the trends in transition elements and their oxidation states, stability theories		
3	A comprehensive understanding of concepts and different properties of lanthanide and actinides		

4	Understanding of metals in biological system and role of trace metals		

SCCH351	**Inorganic Chemistry-III Practicals**	L	T	P	C
Version 3.0		0	0	4	2
Total contact hours	30				
Pre-requisites/Exposure	Gravimetric analysis and inorganic preparations				
Co-requisites	--				

Course Objectives

- To strenghten the students with gravimetric analysis of ions.
- To expertise the students for the preparation of coordination compounds in laboratory

Course Outcomes

On completion of this course, the students will be able to

CO1. To enable the students about general of Gravimetric Analysis and procedure

CO2. Students have knowledge about to estimate the amount of ions in solution

CO3. To enable the student about some experimental techniques of synthesis

CO4. To provide the student basic knowledge of laboratory equipments and chromatography

Catalog Description

This course imparts the understanding of quantitative analysis by gravimetric method and the whole procedure to find out the amount of ions present in solution. This course helps them to get experience of synthesizing coordination complexes with different structures. This course also introduces the chromatography for the separation of ions in solution.

Course Content

(a)Quantitative Analysis: The following quantitative estimations are to be carried out.

(i) Estimation of nickel (II) using Dimethylglyoxime as the precipitant.

(ii) Estimation of copper as CuSCN

(iii) Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$ through (i) Heterogeneous and Homogeneous media.

(iv) Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminiumoxinate).

(b)Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}

(c)Inorganic Preparations:

(i) Tetraammine copper (II) sulphate, $[Cu(NH_3)_4]SO_4 H_2O$

(ii) Potassium trisoxalatochromate (III), $K_3[Cr(C_2O_4)_3]$

(iii) Cis and trans $K[Cr(C_2O_4)_2(H_2O_2]$ Potassium dioxalatodiaquachromate(III)

(iv) Pentaamminecarbonato Cobalt (III) ion

(d) Complexometric Titrations:

(i) Complexometric estimation of (i) Mg^{2+} (ii) Zn^{2+} using EDTA

(ii) Estimation of total hardnesss of water samples

(iii) Estimation of Ca2+ in solution by (substitution method) using Erio-chrome black-T as indicator.

(ii) Estimation of Ca/Mg in drugs and biological samples

Text Books

1. A I Vogel, A text book of Quantitative Inorganic Analysis (Prentice Hall)

Reference Books/Materials

1. G. Marr & B. W. Rockett, Practical Inorganic Chemistry, London; New York : Van Nostrand Reinhold, 1972.
2. O. P Pandey, D.N. Bajpai, S.Giri, Practical chemistry, S. Chand & Company Pvt. Ltd.
3. H.H Willard, L.L Meritt, I.A Dean, Instrumental Methods of Analysis, CBS Publishers, Delhi.
4. W. L. Jolly, The synthesis & characterization of Inorganic compounds, Prentice Hall. R.A. Day and A.L. Underwood, Quantitative Analysis- 3 edition, Prentice Hall India, Pvt. Ltd. New Delhi, 1977.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Components	**Conduct of**	**Lab Record/Quizzes/**	**Attendan**	**End Term**

Weightage	**20**	**20**	**10**	**50**

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Course Code and Title	**Course Outcome**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
SCCH 351 Inorganic Chemistry-III Practicals	**CO1**	3		3										3	
	CO2	3	2											3	
	CO3			3								3			2
	CO4	3			3							3			2

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	(a) Quantitative Analysis, (b) Inorganic Preparations:, (c) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}
Local	-
Regional	-
National	-
Global	(a) Quantitative Analysis, (b) Inorganic Preparations:, (c) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}
Employability	-
Entrepreneurship	-
Skill Development	This course helps them to get experience of synthesizing coordination complexes with different structures. This course also introduces the chromatography for the separation of ions in solution.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-

SDG	Acquire relevant skills, includingtechnical and vocational skills, for employment, decent jobs and entrepreneurship (SDG 4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3) develop good,thoughtful, well-rounded, and creative individuals (9.1.1);Towards a More Holistic and Multidisciplinary Education(11.1- 11.13)
POE/4th IR	Technical Skills that match Industry Needs, Focus on Employability Skills (Local/Regional and Global) Team Work/ Skill Embedded Courses Development, Employability, Entrepreneurship, Skill Development (Chemical Analyst, Chemical Industry)

Teaching Plan

Weekly Teaching Plan	**Topic/Unit No.**	**Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open**	**Teaching-Learning Method**
Week 1	Estimation of nickel (II) using Dimethylglyoxime as the precipitant	**RB-2/OER-I**	**Discussion and Experiment**
Week 2	Estimation of copper as CuSCN	**RB-2/OER-1/2**	**Discussion and Experiment**
Week 3	Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$ through Heterogeneous media	**RB-2/OER-2/3**	**Discussion and Experiment**
Week 4	Estimation of iron as Fe_2O_3 by precipitating iron as Fe(OH)3 through Homogeneous media	**RB-1/2/OER-3**	**Discussion and Experiment**
Week 5	Estimation of Al (III) by precipitating with oxine and weighing as Al(oxine)3 (aluminiumoxinate)	**RB-2/OER-3/4**	**Discussion and Experiment**
Week 6	Inorganic Preparation of Tetraammine copper (II) sulphate, $[Cu (NH_3)_4] SO_4 H_2O$	**RB-2/OER-4**	**Discussion and Experiment**
Week 7	Inorganic Preparation of Potassium trisoxalatochromate (III), $K_3 [Cr (C_2O_4)3]$	**RB-2/OER-5**	**Discussion and Experiment**
Week 8	Inorganic Preparation of Cis $K[Cr(C_2O_4)_2 (H_2O_2]$ Potassium dioxalatodiaquachromate(III)	**RB-2/OER-5**	**Discussion and Experiment**
Week 9	Inorganic Preparation of trans $K[Cr(C_2O_4)_2 (H_2O_2]$ Potassium dioxalatodiaquachromate(III)	**RB-2/OER-5/6**	**Discussion and Experiment**

Week 10	Inorganic Preparation of Pentaamminecarbonato Cobalt (III) ion	**RB-2/OER-6**	**Discussion and Experiment**
Week 11	Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}		**Discussion and Experiment**
Week 12	Revision		**Discussion and Experiment**
Week 13	Revision		**Discussion and Experiment**
Week 14	Revision		**Discussion and Experiment**

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Gain valuable hands-on experience in working with advanced materials and the associated equipment and techniques.	(i) Each experiment to be explained with illustrations. (ii) Students to be encouraged to find out the concentration of compounds using analytical methods and to prepare inorganic compounds (iii) Introduce students to quantitative analysis techniques with gravimetric analysis. (iv) Student prepare some inorganic compounds. (v) Seperation of ions by paper chromatography and identification.	• Experiment Performance and class discussions. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Develop critical skills required for scientific research, such as experimental design, data analysis, and effective communication of scientific findings.		

SCCH303	**Introduction to Quantum Chemistry**	L	T	P	C
Version 2.0		3	1	0	4

Total contact hours	60
Pre-requisites/Exposure	Basics of Chemistry and Calculus
Co-requisites	--

Course Objectives

1. To be able to appreciate the development of quantum mechanics.
2. To understand all the basic terms and postulates of quantum chemistry.
3. To write and solve Schrodinger wave equation for different systems.
4. To learn to carry out qualitative treatment of hydrogen and hydrogen like species.

Course Outcomes

On completion of this course, the students will be able to

CO1: Understand the concepts of black-body radiation, photoelectric effect, quantization, wave-particle duality, and the uncertainty principle.

CO2: Apply the Schrödinger equation to free-particle and particle-in-a-box scenarios, analyze boundary conditions, wave functions, and energies, and comprehend degeneracy in quantum systems, focusing on the hydrogen atom and hydrogenic orbitals.

CO3: Quantitatively analyze the simple harmonic oscillator model, set up the Schrödinger equation, and discuss the solutions of wave functions for this system.

CO4: Qualitatively analyze hydrogen atoms and hydrogen-like ions, set up the Schrödinger equation in spherical polar coordinates, and discuss the radial part and quantization of energy.

Catalog Description

This course imparts the basic concepts quantum mechanics. It enables them to understand the gaps in classical mechanics and how these knowledge gaps could be explained with the emergence of quantum mechanics. The course describes the fundamental terms and equations, the focus will be on Schrodinger wave equation. The course introduces the basic qualitative treatment for hydrogen and hydrogen like species.

Course Content

Unit I: 15 Lectures

Introduction to black-body radiation and distribution of energy, photo-electric effect, conceptofquantization,waveparticleduality(de-Broglie'shypothesis),Theuncertaintyprinciple, The wave function: wave function and its interpretation, conditions of normalization and Orthogonality and its significance. Basic idea about operators, eigen function and values.

Unit II: 15 Lectures

Schrodinger equation and application to free-particle and particle in a box, boundary conditions, wave functions and energies, degeneracy, hydrogen atom, Schrodinger equation in polar coordinates,radialandangularpartsofthehydrogenicorbitals,degeneracies,sphericalharmonics, representations of hydrogenic orbitals.

Unit III: **15 Lectures**

Quantitative treatment of simple harmonic osciallator model, setting up of Schodinger equation and discussion of solution of wave functions.Rigid rotator model and discussion of application of Schrodinger equation.idea about transformation to spherical polar coordinate, discussion on solution,

Unit IV: **15Lectures**

QualitativetreatmentofhydrogenatomandhydrogenJlikeions:settingupofSchrödingerequation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Valence bond and molecular orbital approaches, LCAO-MO treatment of H_2, H^+; bonding and anti-bonding orbitals, Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not$_2$required) and theirlimitations

Text Books

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition(International)1999
2. Levine I. N., *Physical Chemistry,* Fourth Edition), McGraw-Hill (International),1995.
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach,*University Science Books, 1998.

Reference Books/Materials

1. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
2. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA(2004).

Open Educational Resources
https://www.khanacademy.org/
https://ocw.mit.edu/
https://www.coursera.org/
https://www.open.edu/openlearn/
https://www.edx.org/
https://libretexts.org/
https://nptel.ac.in/
https://www.saylor.org/
http://chemcollective.org/
https://openstax.org/

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Programme and Course Mapping

Components	**Quiz/Assignment/**	**Mid Term**	**Atte**	**End Term**
Weightage (%)	**20**	**20**	**10**	**50**

Course code and course name	**COs**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
SCCH303 Introduction to Quantum Chemistry	**CO 1**	3	2	1	2	1	2	2	1	2	1	3	2	2	2
	CO 2	2	3	2	3	1	3	1	3	1	1	2	1	3	2
	CO 3	2	3	3	2	1	2	1	2	2	1	3	1	2	3
	CO 4	1	2	2	3	1	1	2	2	3	2	2	3	2	1

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	Introduction to black-body radiation and distribution of energy, photo-electric effect,
Local	-
Regional	-
National	-
Global	Introduction to black-body radiation and distribution of energy, photo-electric effect
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	Schrodinger equation and application to free-particle and particle in a box

Local	-
Regional	-
National	-
Global	Schrodinger equation and application to free-particle and particle in a box
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment &Sustainability	-
Unit III	Quantitative treatment of simple harmonic oscillator model,
Local	-
Regional	-
National	-
Global	Quantitative treatment of simple harmonic oscillator model,
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Qualitativetreatmentofhydrogen-likeions: hydrogenatom
Local	-
Regional	-
National	-
Global	Qualitativetreatmentofhydrogen-likeions: hydrogenatom
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-

Environment & Sustainability	-
SDG	Knowledge and skills needed to promote, sustainable development (4.7)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Global Education Knowledge, improve general skills for study and career management/ Learning of digitalization of software

Teaching Plan:

Week	Topics/Unit Number	Textbook/Reference Book-Chapter/ Open Educational Resources	Teaching-Learning Method
Week 1	Introduction to Quantum Mechanics (Unit I)	Chapter 1: Black-body radiation, OER Commons, Khan Academy	Lecture, Presentation, Discussion
Week 2	Introduction to Quantum Mechanics (Unit I)	Chapter 2: Photo-electric effect, MIT OCW, YouTube Channels	Lecture, Interactive Activity,
Week 3	Introduction to Quantum Mechanics (Unit I)	Chapter 3: Wave-Particle Duality, Merlot, ChemCollective	Lecture, Simulation, Group
Week 4	Introduction to Quantum Mechanics (Unit I)	Chapter 4: Uncertainty Principle, YouTube Channels	Lecture, Demonstration, Problem
Week 5	Introduction to Quantum Mechanics (Unit I)	Chapter 5: The Wave Function, OER Commons, Khan Academy	Lecture, Examples, Q&A
Week 6	Introduction to Quantum Mechanics (Unit I)	Chapter 6: Operators and Eigenvalues, Chem Collective	Lecture, Problem-Solving,
Week 7	Schrodinger Equation and Particle in a Box	Chapter 7: Schrodinger Equation, MIT OCW, Merlot	Lecture, Derivation, Interactive
Week 8	Schrodinger Equation and Particle in a Box	Chapter 8: Particle in a Box, OER Commons, Khan Academy	Lecture, Experiment, Problem

Week 9	Schrodinger Equation and Particle in a Box	Chapter 9: Boundary Conditions, YouTube Channels, ChemCollective	Lecture, Simulation, Group
Week 10	Schrodinger Equation and Particle in a Box	Chapter 10: Hydrogen Atom, OER Commons, Merlot	Lecture, Examples, Problem-
Week 11	Schrodinger Equation in Polar Coordinates (Unit	Chapter 11: Schrodinger in Polar Coordinates, MIT OCW, YouTube Channels	Lecture, Derivation, Problem-
Wee k 12	Schrodinger Equation in Polar Coordinates (Unit	Chapter 12: Hydrogenic Orbitals, Khan Academy, ChemCollective	Lecture, Examples, Interactive
Wee k 13	Quantitative Treatment of Simple Harmonic	Chapter 13: Harmonic Oscillator, OER Commons, Merlot	Lecture, Simulation, Problem-
Wee k 14	Rigid Rotator Model (Unit III)	Chapter 14: Rigid Rotator Model, MIT OCW, Khan Academy	Lecture, Derivation, Group

Facilitating the Achievement of Course Learning Outcomes

Unit Number	**Course Learning Outcomes (CLOs)**	**Teaching-Learning Activities (TLAs)**	**Assessment Task Methods**
Unit I	Understand black-body radiation, quantization, and wave-particle duality.	- Lectures on black-body radiation, de-Broglie's hypothesis, and wave-particle duality.	- Written examination with questions on black-body radiation and quantization.
Unit II	Apply Schrödinger equation to free-particle and particle in a box scenarios.	- Practical demonstrations of solving Schrödinger equation for free-particle and particle in a box cases.	- Lab reports evaluating the application of Schrödinger equation in different scenarios.
Unit III	Quantitatively analyze the simple harmonic oscillator model.	- Workshops and exercises on setting up the Schrödinger equation for the simple harmonic oscillator and solving wave functions.	- Written tests evaluating the ability to quantitatively analyze the harmonic oscillator.

Unit IV	Qualitatively analyze hydrogen atoms and hydrogen-like ions.	- Interactive sessions and demonstrations on setting up Schrödinger equation in spherical polar coordinates and solving for hydrogen atom.	- Oral or written assessments of qualitative analysis of hydrogen atoms and ions.

SCCH353	**Introduction to Quantum Chemistry Practicals**	L	T	P	C
Version 2.0		0	0	4	2
Total Contact Hours	**30**				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

Course Objectives

1. To be able to learn about basics of computational studies.
2. To build molecular models.
3. To learn to determine enthalpy of isomerization.
4. To take absorbance readings on a colorimeter and use it to verify Beer's law.

Course Outcomes (CO)

On completion of this course, the students will be able to

CO1: Demonstrate a sound understanding of molecular modeling concepts, calculation methods, and software applications in chemistry labs.
CO2: To apply computational tools and software (e.g., Hyper Chem, Gaussian) for molecular modeling and optimization to predict molecular conformations and properties.
CO3: Analyze molecular structures, bond lengths, and electron density maps to interpret molecular properties, dipole moments, and vibrational modes.
CO4: Evaluate experimental data using colorimetry techniques to determine indicator constants and verify Beer's Law for the concentration of solutions.

Catalog Description

This course imparts the basic concepts of quantum chemistry practicals. It enables the students to build molecular models and carry energy calculations of various conformations. The course discusses the concept and usage of a colorimeter and how to find out dissociation constant with the help of absorbance values. The course introduces the Beer's law and protocol required for its verification.

Course Content

List of Experiments

i) The students may be demonstrated hyperchem lab activities – building a molecular model (leveling of atoms, editing individual atoms, changing bond order, centrering, rotation of atoms), Selectionofcalculationmethod(*e.g*.forcefieldcalculation,ab-initiosetup),displayingcalculated properties, (instructor may demonstrate Computer programs that calculate the energy of various conformations of molecules and predict the lowest energy, to learn how to construct or draw representationsofmoleculesusingamolecularmodelingprogramcalledHyperChem(HyperCube, Inc.), to perform geometry optimizations (energy minimizations) to determine the lowest energy conformations ofmolecules).

(Depending upon the availability of infrastructure facilities, instructor can demonstrate the students use of hyperchem software, Gaussian software – geometry optimization). They can be allowedforacademicvisittocomputationallabstogainknowledgeandareportmaybeconsidered forvivavoce/examination).Opensourcesoftwaresmaybeusedforlabdemonstrationandstudents may prepare a report along with viva-voce shall constitute practical examination. Instructor may encourage the students to gain hand-on experience in using open-source softwares (forperfoming various calculation as mentioned) in lab computers, periodic evaluation of which can also be accepted as conducting lab practical examination. Basic idea is to encourage the students to get knowledge without keeping any rigid practical syllabusframework).

(Examples of the computational work that can be done: Compare the optimized C-C bondlengths in ethane, ethene, ethyne and benzene. Visualize the molecular orbitals of the ethane σ bonds and ethene, ethyne, benzene and pyridine πbonds.

ii) (a) Performaconformationalanalysisofbutane.(b)Determinetheenthalpyofisomerizationof *cis* and *trans* 2-butene.

iii) Visualize the electron density and electrostatic potential maps for LiH, HF, N_2, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of thesemolecules. (Software: Chem Sketch, ArgusLab (www.planaria-software.com),TINKER6.2 (dasher.wustl.edu/ffe), WebLab Viewer, Hyperchem, or any similarsoftware.

iv) Determination of indicator constant -colorimetry.
v) Verification of Beer's Law - Determination of concentration of solution bycolorimetry.

Suggested books/reference books:

1.Essentials of computational chemistry – Theories and models, C. J. Crammer, Wiley, 2nd Edn.,

2.Principle and applications of quantum chemistry, V.K.Gupta, Elsevier, 2016.

3. Practicals in physical chemistry – a modern approach, P.S.Sindhu,Macmillan,

4. Experiments in Physical Chemistry, J.M.Wilson, R.J.Newcomb, A.R.Denaro, 2nd Edn., Elsevier.

5. A.R. Leach, *Molecular Modelling Principles and Application*, Longman,2001.

6. J.M. Haile, *Molecular Dynamics Simulation Elementary Methods*, John Wiley and Sons,1997.

7. Gupta, S.P. *QSAR and Molecular Modeling*, Springer - Anamaya Publishers,2008.

Open Educational Resources (OER)

Hyperchem ;https://www.hyper.com/
Gaussian: https://gaussian.com/
ChemCollective: http://chemcollective.org/
Khan Academy: https://www.khanacademy.org/
MIT OpenCourseWare: https://ocw.mit.edu/index.htm
Merlot: https://www.merlot.org/merlot/index.htm
ChemSketch: https://www.acdlabs.com/products/draw_nom/chemsketch/
Argus Lab: http://www.arguslab.org/
TINKER 6.2: http://dasher.wustl.edu/ffe/
WebLab Viewer: https://weblab-viewer.org/

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Compone	Conduct of	Lab Record/Quizzes/	Attendan	End Term
Weighta	20	20	10	50

Programme and Course Mapping

Course code and Title	Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2	PSO 3	PSO 4
SCCH353 Introduction to Quantum Chemistry Practicals	CO1	3	2	2	3	2	3	1	1	2	2	3	2	2	1
	CO2	3	3	1	2	1	2	1	1	2	2	2	2	2	1
	CO3	2	2	2	2	1	2	1	1	2	1	3	1	2	1
	CO4	1	1	1	3	1	1	2	2	1	1	1	3	3	3

Unit I	i)Hyperchem lab activities

	ii) (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of cis and trans 2-butene. iii) Visualize the electron density and electrostatic potential maps for LiH, HF, N2, NO and CO and comment. Relate to the dipole moments. iv) Determination of indicator constant - colorimetry. v) Verification of Beer's Law - Determination of concentration of solution by colorimetry.
Local	-
Regional	-
National	-
Global	-
Employability	hyperchem lab activitiesii) (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of cis and trans 2-butene
Entrepreneurship	-
Skill Development	Hands-on-Experience of different software like hyperchem , Gaussian, Projects (in industry/ research lab)
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Acquire relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship (SDG 4.4),
NEP	Towards a More Holistic and Multidisciplinary Education 11.1- 11.13), Promoting High Quality Research (18.1-18.9); Technology Use and Integration;
POE/4th IR	Technical Skills that match Industry Needs;Focus on Employability Skills (Local/Regional and Global)Team Work, Technology Use and Integration (23.1-23.13), Interenship Program; Consulting Field Projects/ Hands-on-Experience of different software like hyperchem , Gaussian, Projects (in industry/ research lab)

Teaching Plan:

Week	Topics / Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Method
1	Introduction to Molecular Modeling	RB: Chemistry Fundamentals	OER: Molecular Modeling
2	HyperChem Lab Activities	OER: HyperChem Manual	
3	Building Molecular Models	OER: Molecular Modeling	
4	Calculation Methods	OER: Computational Chemistry	
5	Displaying Calculated	OER: Computational Chemistry	

	Properties		
6	Introduction to Gaussian Software	RB: Gaussian Manual	
7	Geometry Optimization using Gaussian	RB: Gaussian Manual	
8	Conformational Analysis of Butane	TB: Ch. 3, Pg. 45-52	
9	Enthalpy of Isomerization of Butene	TB: Ch. 4, Pg. 67-74	
10	Visualizing Electron Density and Potential Maps	RB: Computational Chemistry	OER: ChemSketch, ArgusLab
11	Dipole Moments and Molecular Vibrations	RB: Physical Chemistry	
12	Determination of Indicator Constant	TB: Ch. 8, Pg. 145-152	
13	Verification of Beer's Law	TB: Ch. 8, Pg. 153-158	
14	Recap and Review		

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activities	Assessment Task Methods
1	Understand Molecular Modeling and Calculation Methods	Lectures on molecular modeling and software	Quiz on molecular modeling concepts
2	Explore Hyper Chem Lab Activities	Demonstration of HyperChem lab activities	Lab report on HyperChem activities
3	Learn Building Molecular Models and Calculation Techniques	Hands-on practice	

SEC010	**Intellectual property right (IPR) and business skills for chemists**	L	T	P	C
Version 1.0		2	0	0	2
Total Contact hours	30				
Pre-requisites/Exposure	NA				
Co-requisites	--				

Course Objectives

1. To aware the students about the Intellectual Property Rights.
2. To familiarize the students with the different types of IP and importance of protecting IP.
3. To give an understanding of the IP laws in International prospective.
4. To explain the key business concepts and current challenges and opportunities in the market.

Course Outcomes

On completion of this course, the students will be able to

CO1. Remember fundamental concepts and principles of intellectual property rights (IPR) related to chemistry.

CO2. Understand the importance of IPR in promoting innovation, protecting inventions, and fostering business growth.

CO3. Apply strategies and techniques for conducting intellectual property searches, prior art analysis, and patent landscape assessments.

CO4. Analyze and evaluate real-world case studies and scenarios involving intellectual property rights in the chemical industry.

CO5. Evaluate the competitive landscape and identify opportunities for leveraging intellectual property assets to gain a competitive advantage in the chemical industry.

CO6. Create a comprehensive intellectual property protection plan for a hypothetical chemical invention or innovation.

Catalog Description

This Intellectual property has increasingly assumed a vital role with the rapid pace of technological, scientific and medical innovation that we are witnessing today. Moreover, changes in the global economic environment have influenced the development of business models where intellectual property is a central element establishing value and potential growth. In India several new legislations for the protection of intellectual property rights (IPRs) have been passed to meet the international obligations under the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). Intellectual property has therefore grown into one of the world's biggest and fastest-growing fields of law thereby necessitating the demand for IP professionals well versed in this area to deal with (IPRs) across the national and intern

The study of different International agreements as Word Trade Organization (WTO), Paris Convention helps in understanding various laws in India Licensing and technology transfer. The application of Chemistry in Industry makes clear the current challenges and opportunities for the chemistry-using industries, its role in India and global economies and Financial aspects of business with case studies for better knowledge.

Course Content

UNIT I 16 Lectures

Introduction to Intellectual Property: Historical Perspective, Different Types of IP, Importance of protecting IP. Copyrights Introduction, How to obtain, Differences from Patents. Trade Marks Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, Trade names, etc. Differences from Designs.Patents Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India.

UNIT II14 Lectures

Geographical Indications Definition, rules for registration, prevention of illegal exploitation, importance to India. Industrial Designs Definition, How to obtain, features, International design registration. Layout design of integrated circuits Circuit Boards, Integrated Chips, Importance for electronic industry. Trade Secrets Introduction, Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

UNIT III 16 Lectures

Different International agreements
1. World Trade Organization (WTO):
(i) General Agreement on Tariffs & Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement
(ii) General Agreement on Trade related Services (GATS)
(iii) Madrid Protocol
(iv) Berne Convention
(v) Budapest Treaty
2. Paris Convention WIPO and TRIPS, IPR and Plant Breeders Rights, IPR and Biodiversity IP Infringement issue and enforcement – Role of Judiciary, Role of law enforcement agencies – Police, Customs etc.

UNIT IV 14 Lectures

Business Basics Key business concepts: Business plans, market need, project management and routes to market. **Chemistry in Industry** Current challenges and opportunities for the chemistry-using industries, role of chemistry in India and global economies. **Financial aspects** Financial aspects of business with case studies.

Text Books

1. V.K AHUJA, Law Relating to INTELLECTUAL PROPERTY RIGHTS, Lexis Nexis.

Reference Books/Materials

1. Guru, M. & Rao, M.B. Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications (2003).

2. Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw- Hill (2001).

3. Miller, A.R. & Davis, M.H. Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers (2000).

4. Watal, J. Intellectual property rights in the WTO and developing countries, Oxford University Press, New Delhi.

Open Educational Resources (OER)

- https://openstax.org/details/books/introduction-business
- https://www.copyright.gov/
- https://www.wipo.int/trademarks/en/
- https://www.wipo.int/designs/en/
- https://www.wipo.int/treaties/en/
- https://www.wto.org/index.htm

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Components	**Conduct of**	**Lab Record/Quizzes/**	**Attendan**	**End Term**
Weightage	**20**	**20**	**10**	**50**

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Course Code and Title	**Course Outcome**	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2	PSO 3	PSO 4
SEC010 **Intellectual property right (IPR) and business skills for chemists**	**CO1**	1		2		3			3						
	CO2			1							3			1	
	CO3			1			3		2			2		2	
	CO4			3	3					3				2	
	CO5		1					3					3		
	CO6														

1=weakly mapped

2= moderately mapped
3=strongly mapped

Unit I	Introduction to Intellectual Property
Local	The course content is relevant locally as it addresses the importance of intellectual property protection and business concepts in the local context. It enables students to understand and navigate the local intellectual property landscape, supporting local businesses and innovations.
Regional	Knowledge of Intellectual Property and business concepts contributes to regional development by fostering innovation, entrepreneurship, and economic growth. It enables the region to protect and commercialize its intellectual assets, attracting investments and promoting regional competitiveness.
National	The course content aligns with national priorities of promoting innovation, entrepreneurship, and economic development. It equips students with the knowledge and skills required to protect intellectual property, commercialize innovations, and contribute to the nation's intellectual and economic growth.
Global	Intellectual Property is a global issue, and understanding its principles and international agreements is essential for global engagement. The course content provides insights into international IP agreements, WIPO, and global IP enforcement mechanisms, enabling students to participate in the global knowledge economy.
Employability	Knowledge of Intellectual Property and business concepts enhances employability in various sectors, including research and development, technology transfer, legal and regulatory affairs, and innovation management. It equips students with skills that are highly valued by employers in these domains.
Entrepreneurship	The course content on Intellectual Property, business concepts, and financial aspects provides a solid foundation for entrepreneurship. It equips students with the knowledge and skills needed to protect their innovations, develop business plans, understand market needs, and manage projects, fostering their entrepreneurial spirit.
Skill Development	The course content enhances various skills, including critical thinking, analytical skills, legal understanding, strategic planning, and financial management. It equips students with skills that are essential for successful careers in intellectual property management, business, and entrepreneurship.
Professional Ethics	The course emphasizes the importance of ethical conduct in relation to intellectual property protection, enforcement, and business practices. It highlights the ethical responsibilities of individuals and organizations regarding the fair use of intellectual property and compliance with relevant laws and regulations.
Gender	-
Human Values	The course content promotes values such as creativity, innovation, fairness, integrity, and respect for intellectual property rights. It instills an understanding of the value of knowledge, creativity, and ethical practices in fostering human development and societal progress.

Environment & Sustainability	-
Unit II	Different International agreements
Local	The course content is relevant locally as it addresses the importance of intellectual property protection and business concepts in the local context. It enables students to understand and navigate the local intellectual property landscape, supporting local businesses and innovations.
Regional	Knowledge of Intellectual Property and business concepts contributes to regional development by fostering innovation, entrepreneurship, and economic growth. It enables the region to protect and commercialize its intellectual assets, attracting investments and promoting regional competitiveness.
National	The course content aligns with national priorities of promoting innovation, entrepreneurship, and economic development. It equips students with the knowledge and skills required to protect intellectual property, commercialize innovations, and contribute to the nation's intellectual and economic growth.
Global	Intellectual Property is a global issue, and understanding its principles and international agreements is essential for global engagement. The course content provides insights into international IP agreements, WIPO, and global IP enforcement mechanisms, enabling students to participate in the global knowledge economy.
Employability	Knowledge of Intellectual Property and business concepts enhances employability in various sectors, including research and development, technology transfer, legal and regulatory affairs, and innovation management. It equips students with skills that are highly valued by employers in these domains.
Entrepreneurship	The course content on Intellectual Property, business concepts, and financial aspects provides a solid foundation for entrepreneurship. It equips students with the knowledge and skills needed to protect their innovations, develop business plans, understand market needs, and manage projects, fostering their entrepreneurial spirit.
Skill Development	The course content enhances various skills, including critical thinking, analytical skills, legal understanding, strategic planning, and financial management. It equips students with skills that are essential for successful careers in intellectual property management, business, and entrepreneurship.
Professional Ethics	The course emphasizes the importance of ethical conduct in relation to intellectual property protection, enforcement, and business practices. It highlights the ethical responsibilities of individuals and organizations regarding the fair use of intellectual property and compliance with relevant laws and regulations.
Gender	-
Human Values	The course content promotes values such as creativity, innovation, fairness, integrity, and respect for intellectual property rights. It instills an understanding of the value of knowledge, creativity, and ethical practices in fostering human development and societal progress.
Environment &	-

Sustainability	
Unit III	Different International agreements
Local	The course content is relevant locally as it addresses the importance of intellectual property protection and business concepts in the local context. It enables students to understand and navigate the local intellectual property landscape, supporting local businesses and innovations.
Regional	Knowledge of Intellectual Property and business concepts contributes to regional development by fostering innovation, entrepreneurship, and economic growth. It enables the region to protect and commercialize its intellectual assets, attracting investments and promoting regional competitiveness.
National	The course content aligns with national priorities of promoting innovation, entrepreneurship, and economic development. It equips students with the knowledge and skills required to protect intellectual property, commercialize innovations, and contribute to the nation's intellectual and economic growth.
Global	Intellectual Property is a global issue, and understanding its principles and international agreements is essential for global engagement. The course content provides insights into international IP agreements, WIPO, and global IP enforcement mechanisms, enabling students to participate in the global knowledge economy.
Employability	Knowledge of Intellectual Property and business concepts enhances employability in various sectors, including research and development, technology transfer, legal and regulatory affairs, and innovation management. It equips students with skills that are highly valued by employers in these domains.
Entrepreneurship	The course content on Intellectual Property, business concepts, and financial aspects provides a solid foundation for entrepreneurship. It equips students with the knowledge and skills needed to protect their innovations, develop business plans, understand market needs, and manage projects, fostering their entrepreneurial spirit.
Skill Development	The course content enhances various skills, including critical thinking, analytical skills, legal understanding, strategic planning, and financial management. It equips students with skills that are essential for successful careers in intellectual property management, business, and entrepreneurship.
Professional Ethics	The course emphasizes the importance of ethical conduct in relation to intellectual property protection, enforcement, and business practices. It highlights the ethical responsibilities of individuals and organizations regarding the fair use of intellectual property and compliance with relevant laws and regulations.
Gender	-
Human Values	The course content promotes values such as creativity, innovation, fairness, integrity, and respect for intellectual property rights. It instills an understanding of the value of knowledge, creativity, and ethical practices in fostering human development and societal progress.
Environment & Sustainability	-

Unit IV	
Local	The course content is relevant locally as it addresses the importance of intellectual property protection and business concepts in the local context. It enables students to understand and navigate the local intellectual property landscape, supporting local businesses and innovations.
Regional	Knowledge of Intellectual Property and business concepts contributes to regional development by fostering innovation, entrepreneurship, and economic growth. It enables the region to protect and commercialize its intellectual assets, attracting investments and promoting regional competitiveness.
National	The course content aligns with national priorities of promoting innovation, entrepreneurship, and economic development. It equips students with the knowledge and skills required to protect intellectual property, commercialize innovations, and contribute to the nation's intellectual and economic growth.
Global	Intellectual Property is a global issue, and understanding its principles and international agreements is essential for global engagement. The course content provides insights into international IP agreements, WIPO, and global IP enforcement mechanisms, enabling students to participate in the global knowledge economy.
Employability	Knowledge of Intellectual Property and business concepts enhances employability in various sectors, including research and development, technology transfer, legal and regulatory affairs, and innovation management. It equips students with skills that are highly valued by employers in these domains.
Entrepreneurship	The course content on Intellectual Property, business concepts, and financial aspects provides a solid foundation for entrepreneurship. It equips students with the knowledge and skills needed to protect their innovations, develop business plans, understand market needs, and manage projects, fostering their entrepreneurial spirit.
Skill Development	The course content enhances various skills, including critical thinking, analytical skills, legal understanding, strategic planning, and financial management. It equips students with skills that are essential for successful careers in intellectual property management, business, and entrepreneurship.
Professional Ethics	The course emphasizes the importance of ethical conduct in relation to intellectual property protection, enforcement, and business practices. It highlights the ethical responsibilities of individuals and organizations regarding the fair use of intellectual property and compliance with relevant laws and regulations.
Gender	-
Human Values	The course content promotes values such as creativity, innovation, fairness, integrity, and respect for intellectual property rights. It instills an understanding of the value of knowledge, creativity, and ethical practices in fostering human development and societal progress.
Environment & Sustainability	-
SDG	The course content on Intellectual Property (IP) highlights the importance of

	protecting innovations and promoting creativity, which contributes to SDG 9: Industry, Innovation, and Infrastructure. It encourages the development and utilization of IP rights to foster innovation and support sustainable economic growth.
NEP	The course content aligns with NEP's focus on promoting a holistic and multidisciplinary education. It provides knowledge about intellectual property rights, business concepts, and financial aspects, enhancing students' understanding of the broader socio-economic context and fostering their entrepreneurial and innovative mindset.
POE/4th IR	Understanding Intellectual Property and its various forms is crucial in the context of the Fourth Industrial Revolution. The course equips students with knowledge about copyrights, trademarks, patents, and trade secrets, which are vital for protecting and commercializing innovations in the digital age.

Teaching Plan:

Week	Topics Covered	Reference Books / Materials	Teaching-Learning Methods
1	Introduction to Intellectual Property	Textbook: V.K Ahuja	Lecture, Discussion
2	Different Types of IP, Importance	Textbook: V.K Ahuja	Lecture, Case Studies
3	Copyrights: Introduction and Obtaining	Textbook: V.K Ahuja	Lecture, Group Discussions
4	Copyrights vs. Patents	Textbook: V.K Ahuja	Lecture, Comparative Analysis
5	Trademarks: Introduction and Obtaining	Textbook: V.K Ahuja	Lecture, Case Studies
6	Types of Marks, Trade Names	Textbook: V.K Ahuja	Lecture, Group Activities
7	Patents: Historical Perspective	Textbook: V.K Ahuja	Lecture, Guest Speaker (Patent Expert)
8	WIPO, PCT System, Traditional Knowledge	Textbook: V.K Ahuja	Lecture, Research Assignments
9	Geographical Indications, Registration	Reference: Guru & Rao (2003)	Lecture, Case Studies
10	Industrial Designs, International Reg.	Reference: Ganguli (2001)	Lecture, Design Review Exercise
11	Layout Design of Integrated Circuits	Reference: Miller & Davis (2000)	Lecture, Hands-on Lab (if possible)
12	Trade Secrets: Introduction, Protection	Reference: Watal (Oxford University Press)	Lecture, Legal Case Analysis

13	International Agreements (WTO, TRIPS)	Reference: Watal (Oxford University Press)	Lecture, Group Debates
14	Business Concepts, Chemistry in Industry	Textbook: V.K Ahuja	Lecture, Business Simulation Game

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning Outcomes (CLO)	Teaching-Learning Activities	Assessment Task Methods
Unit I	1. Understand the types of IP	Lecture, group discussions, case studies	Quiz, group presentations
	2. Differentiate copyrights and patents	Comparative analysis, research assignments	Written exam, research paper
	3. Explain trademark concepts	Lecture, group activities, real-world examples	In-class assessment, case study analysis
	4. Explore the history of patents	Lecture, guest speaker (Patent Expert)	Class participation, Q&A session
Unit II	1. Understand Geographical Indications	Lecture, case studies, legal case analysis	Quiz, group presentations
	2. Explain industrial design concepts	Lecture, design review exercise, lab (if possible)	Design review, lab assessment
	3. Discuss the importance of trade secrets	Lecture, legal case analysis, group debates	Case study analysis, debate assessment
	4. Describe risks involved in trade secret protection	Lecture, real-world examples, legal aspects discussion	Case analysis, class participation
Unit III	1. Understand key international agreements	Lecture, group debates, discussions	Group debates, Q&A session
	2. Explain the role of judiciary in IP infringement	Lecture, legal case studies, discussions	Case analysis, class participation
	3. Discuss the role of law enforcement agencies	Lecture, case studies, interaction with law enforcement professionals	Case analysis, interaction assessment
	4. Explore the impact of IP infringement on innovation	Lecture, research assignments, group discussions	Research paper, group presentations
Unit IV	1. Understand key business concepts	Lecture, business simulation game, discussions	Game assessment, class participation
	2. Explain the role of chemistry in industries	Lecture, hands-on lab (if possible), real-world examples	Lab assessment, in-class discussions
	3. Discuss financial aspects of business	Lecture, case studies, financial analysis exercises	Case analysis, financial analysis assignment
	4. Apply IP knowledge to real-world business scenarios	Case studies, group projects, real-world IP issues analysis	Group projects, case analysis

SEMESTER-VI

SCCH302	**Organic Spectroscopy**	L	T	P	C
Version 3.0		3	1	0	4
Total Contact Hours	60				
Pre-requisites/Exposure	12^{th} level Chemistry				
Co-requisites	--				

Course Objectives

In this course students will learn and understand the basic concepts of spectroscopy, difference between emission and absorption spectroscopy, laws of photochemistry, basic principles and working of UV-Visible, IR, NMR, Mass Spectroscope and how structure of organic molecules can be predicted based on UV-Visible, IR, NMR and mass spectrum.

Course Outcomes

On completion of this course, the students will be able to

CO1: Gain knowledge about the basic concept of absorption and emission spectroscopy, fundamentals of UV-Visible spectroscopy.

CO2: Learn the principle of instrumentation and applications of IR, ^{1}H NMR and ^{13}C spectroscopy.
CO3: Understand the mass fragmentation pattern of organic compounds.
CO4: Analyze IR, UV, NMR, Mass spectrometry data and elucidate the structure of simple organic molecules based upon that data.

Catalog Description

Number of organic compounds is synthesized in the laboratories as they are used for several applications such as pesticides, food, cosmetics, essential oils, fats and oils, medicines, paints and varnishes, polymers etc. It is important to understand and establish their structure based on spectroscopic tools such as UV-Visible, IR, NMR and Mass spectroscopy. While on one hand, UV-Visible confirms saturation and unsaturation in the molecule on the other hand IR helps to find out the type of functional group present in the organic molecule. NMR determines the number and type of protons or ^{13}C in the molecule and mass spectroscopy determines the molecular ion peak. In short, all this helps in characterization or structural elucidation of the organic moiety. In this course, the focus will be on thorough understanding of concepts of spectroscopy through class room teaching, video lectures, expert talks and analysis of data available for known compounds. Large number of practice problems will be discussed so that students acquire the technique and knowledge to handle the subject in appropriate manner.

Course Content

UNIT I

Basic Principles of UV Spectroscopy:

Application of Woodward-Fieser rule in interpretation of Organic compounds: Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronictransitions,λmax&εmax,chromophore,auxochrome,bathochromicandhypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λmax of conjugated dienes and α,β – unsaturatedcompounds.

UNIT II

Basic principles of IR Spectroscopy:

Identification of Functional groups of various classes of organic compounds: Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

UNIT III

NMR (^{1}H and ^{13}C NMR):

Application of Chemical Shifts, Splitting of signals, Spin coupling and Over Houser effect in interpretation of NMR spectra, Isotopic exchange

UNIT IV

Basic principles Mass Spectrometry:

Applicationoffragmentationruleincharacterizationoforganiccompounds.Problemsonstructure elucidation of organic compounds based on spectraldata.

Recommended Books/References:

1. R.M. Silverstein, G.C. Bassler & T.C. Morrill*: Spectroscopic Identification of Organic Compounds*, John Wiley &Sons.
2. John R. Dyer, Applications of absorption spectroscopy of organic compounds, Prentice Hall India (2012).
3. Y. R. Sharma, Elementary Organic Spectroscopy, S. Chand

Open Educational Resources (OER)

Introduction to Organic Spectroscopy - Chemistry LibreTexts

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Components	Quiz/Assignment/	Mid Term	Attendance	End Term
Weightage	20	20	10	50

Programme and Course Mapping

Course Code and Title	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SCCH302 ORGANIC SPECTROSCOPY	CO1	3	3	3	3	3	3	2		3		3	3	3	3
	CO2	3	3	3	3	3	3	2		3		3	3	3	3
	CO3	3	3	3	3	3	3	2		3		3	3	3	3
	CO4	3	3	3	3	3	3	2		3		3	3	3	3
	CO5	3	3	3	3	3	3	2		3		3	3	3	3
	CO6	3	3	3	3	3	3	2		3		3	3	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	Basic Principles of UV Spectroscopy
Local	-
Regional	-
National	-
Global	-
Employability	Employability as Analyst in Chemical Industry ,
Entrepreneurship	-
Skill Development	Analytical and logical skill development and Interpretation of data and identification of chemical structures
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	Basic principles of IR Spectroscopy
Local	-
Regional	-
National	-

Global	-
Employability	Employability as Analyst in Chemical Industry ,
Entrepreneurship	-
Skill Development	Analytical and logical skill development and Interpretation of data and identification of chemical structures
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Unit III: NMR (1H and 13C NMR)
Local	-
Regional	-
National	-
Global	-
Employability	Employability as Analyst in Chemical Industry ,
Entrepreneurship	-
Skill Development	Analytical and logical skill development and Interpretation of data and identification of chemical structures
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	UNIT IV: Basic principles Mass Spectrometry
Local	-
Regional	-
National	-
Global	-
Employability	Employability as Analyst in Chemical Industry ,
Entrepreneurship	-
Skill Development	Analytical and logical skill development and Interpretation of data and identification of chemical structures
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	SDG 4.3: Quality Education and skills for employability 4.4
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India’s Higher Education System focusing on intellectual curiosity, scientific temper,(9.1)

	.
POE/4th IR	Employability as Analyst in Chemical Industry , Analytical and logical skill development and Interpretation of data and identification of chemical structures

Teaching Plan:

Weekly Teaching	**Topic/Unit No.**	**Textbook [TB]/ Reference Book**	**Teaching-Learning Method**
Week 1	Basic Principles of UV Spectroscopy	**TB3-2**	Lecture, Discussion
Week 2	Basic Principles of UV Spectroscopy	**TB3-2**	Lecture, Problem solving
Week 3	Basic Principles of UV Spectroscopy	**TB3-2**	Lecture, Problem solving
Week 4	Basic Principles of UV Spectroscopy	**TB3-2**	Lecture, Problem solving
Week 5	Basic principles of IR Spectroscopy	**TB3-3**	Lecture, Discussion
Week 6	Basic principles of IR Spectroscopy	**TB3-3**	Lecture, Problem solving
Week 7	Basic principles of IR Spectroscopy	**TB3-3**	Lecture, Problem solving
Week 8	Basic principles of IR Spectroscopy	**TB3-3**	Lecture, Problem solving
Week 9	NMR (1H and 13C NMR	**TB3-5**	Lecture, Discussion
Week 10	NMR (1H and 13C NMR	**TB3-5**	Lecture, Problem solving
Week 11	NMR (1H and 13C NMR	**TB3-5**	Lecture, Problem solving
Week 12	NMR (1H and 13C	**TB3-5**	Lecture, Problem solving
Week 13	Basic principles Mass Spectrometry	**TB3-7**	Lecture, Discussion
Week 14	Basic principles Mass Spectrometry	**TB3-7**	Lecture, Problem solving
Week 15	Basic principles Mass Spectrometry	**TB3-7**	Lecture, Problem solving
Week 16	Basic principles Mass Spectrometry	**TB3-7**	Lecture, Problem solving

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Understand the fundamental principles of UV spectroscopy, including the interaction of light with molecules and electronic transitions. Interpret UV spectra to determine the electronic transitions and energies of compounds. Correlate UV absorption peaks with the nature of chromophores	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Grasp the basic principles of infrared (IR) spectroscopy, focusing on molecular vibrations and dipole moments. Analyze IR spectra to identify functional groups and bond vibrations in organic compounds. Relate characteristic absorption bands in IR spectra to specific types of functional groups.		
3	Acquire a solid foundation in nuclear magnetic resonance (NMR) spectroscopy, understanding the principles of nuclear spin and resonance. Differentiate between 1H NMR and 13C NMR spectroscopy, recognizing their applications and strengths. Interpret NMR spectra to		
4	Comprehend the basic principles of mass spectrometry, including ionization, fragmentation, and mass-to-charge ratio analysis. Analyze mass spectra to identify molecular weights, fragmentation patterns, and isotopic distributions of compounds. Employ mass spectrometry as a powerful tool for compound		

SCCH401	**Research Methodology**	L	T	P	C
Version 3.0		4	0	0	4
Total contact hours	60				
Pre-requisites/Exposure					
Co-requisites	--				

COURSE OBJECTIVES

The course will enable the student-teacher to:

- Master literature survey techniques for efficient chemical information retrieval.
- Develop proficiency in ethical scientific communication and proper citation practices.
- Acquire knowledge of safe chemical handling and disposal, adhering to ethical guidelines.
- Gain expertise in accurate data analysis, utilizing statistical tools and chemometrics.
- Foster research aptitude through understanding the scientific method and experimental design in chemistry.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Learn to find and use various types of chemical information sources.

CO2: Digital Proficiency: Utilize digital tools for accessing and staying updated on chemistry research.

CO3: Scientific Writing: Develop skills for writing research papers with integrity and precision.

CO4: Safety and Ethics: Understand and practice safe chemical handling and ethical conduct.

CO5: Data Analysis: Gain expertise in analyzing chemical data using statistical techniques.

CO6: Research Competence: Build a solid foundation for conducting meaningful chemistry research.

CATALOG DESCRIPTION

This course introduces students to essential research methodologies in chemistry. It covers effective information sourcing from diverse print and digital resources, emphasizing literature survey techniques, accessing e-journals, and utilizing databases. Scientific writing skills are honed through proper citation practices, methods description, and ethical considerations. Chemical safety protocols, hazardous material handling, and ethical waste disposal are comprehensively addressed. Statistical data analysis techniques, including correlation, regression, and ANOVA, are taught for sound research interpretation. The course cultivates research aptitude, emphasizing the scientific method, experimental design, and critical analysis in the context of chemistry.

COURSE CONTENT

UNIT I: 15 Lecture

Literature Survey:

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples. Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus.

UNIT II 15 Lecture

Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work.Writing ethics.Avoiding plagiarism.

UNIT III 15 Lecture

Chemical Safety and Ethical Handling of Chemicals:Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

UNIT IV 15 lecture

Data Analysis

The Investigative Approach: Making and Recording Measurements. SI Units and their use.Scientific method and design of experiments. Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r and its abuse. Basic aspects of multiple linear regression analysis

Suggested Text Books

1. "Chemical Information for Chemists: A Primer" by Judith N. Currano and Dana L. Roth
2. "Scientific Writing and Communication: Papers, Proposals, and Presentations" by Angelika H. Hofmann
3. "Chemistry Safety for Students and Practitioners: Laboratory Safety for Chemistry Students" by Robert H. Hill Jr. and David C. Finster
4. "Basic Statistics for the Behavioral Sciences" by Gary W. Heiman
5. "Experimental Design for the Life Sciences" by Graeme D. Ruxton and Nick Colegrave
6. Reference Books:
7. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011)
8. Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
9. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
10. Topping, J. (1984) Errors of observation and their treatment.Fourth Ed., Chapman Hall, London.
11. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
12. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis.Cambridge Univ. Press (2001) 487 pages.
13. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
14. OSU safety manual 1.01.

Open Educational Resources (OER)

ChemCollective - Provides virtual labs and scenarios for teaching chemistry concepts: ChemCollective

ChemGuide - A collection of online chemistry resources including tutorials and quizzes: ChemGuide

MIT OpenCourseWare: Principles of Chemical Science - Offers free course materials, including lecture notes and assignments: MIT OCW - Principles of Chemical Science

ChemCollective Virtual Labs - Interactive virtual labs for various chemistry topics: ChemCollective Virtual Labs

Project Gutenberg - Provides free access to a wide range of classic scientific literature: Project Gutenberg

Merlot Chemistry Portal - A collection of chemistry resources from various universities and institutions: Merlot Chemistry

Chem1 Virtual Textbook - An extensive collection of chemistry tutorials and explanations: Chem1 Virtual Textbook

ChemCollective Concept Tests - Interactive concept tests for assessing understanding of chemistry concepts: ChemCollective Concept Tests

OpenStax Chemistry - A comprehensive open-source chemistry textbook: OpenStax Chemistry

Khan Academy Chemistry - Offers free video lessons and practice exercises on various chemistry topics: Khan Academy Chemistry

Assessment & Evaluation

Components	Assignment/P	Mid Term Examination	Attendance	End Term Examination
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course Code	Course Outco	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PS O1	PS O2	PS O3	PS O4
SCCH401 Research Methodology	CO1	2	2	1	3	1	2	2	1	1	1	3	2	1	2
	CO2	1	2	1	2	1	2	2	2	1	1	2	3	1	2
	CO3	2	2	2	2	2	3	1	2	2	2	2	1	1	2
	CO4	2	1	1	3	3	2	1	1	2	2	2	2	1	2
	CO5	2	2	1	2	1	2	1	1	1	1	1	2	1	2
	CO6	1	3	1	2	1	2	2	3	2	3	3	2	1	3

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/	Teaching-Learning Method
1-2	Unit I - Literature Survey	TB-Chapters 1-2	Lectures, Discussions
3-4	Unit I - Literature Survey	TB-Chapters 3-4	Lectures, Case Studies
5-6	Unit II - Information Technology	TB-Chapters 5-6	Lectures, Group Discussions
7-8	Unit II - Information Technology	TB-Chapters 7-8	Lectures, Case Studies

9-10	Unit III - Chemical Safety	TB-Chapters 9-10	Lectures, Guest Lecture
11-12	Unit III - Chemical Safety (cont.)	TB-Chapters 11-12	Lectures, Practical Demonstrations
13-14	Unit IV - Data Analysis	TB-Chapters 13-14	Lectures, Field Trip

Facilitating the Achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching Learning Activity**	**Assessment Task Methods**
1	Literature Survey: Students will learn to navigate various chemical literature sources, from print to digital, distinguishing between primary, secondary, and tertiary sources. They will effectively utilize databases, grasp journal abbreviations, and understand abstracts for staying updated with current research.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Unit II - Information Technology and Library Resources: Through this unit, students will develop digital proficiency, accessing e-journals, web resources, and tools for scientific research. They will master ethical scientific writing, ensuring clear communication through proper citations, both orally and in writing.		
3	Unit III - Chemical Safety and Ethical Handling: This unit will equip students with essential chemical safety knowledge, enabling them to work safely in labs. They will also gain an understanding of ethical considerations related to chemical research and responsible waste disposal.		
4	Unit IV - Data Analysis: Students will acquire expertise in accurate measurement, statistics, and data analysis relevant to chemistry. They will learn to interpret results effectively, supporting evidence-		

	based conclusions and contributing to scientific discussions.		

SEMESTER-VIII

SCCH402	**Research Project**	L	T	P	C
Version 1.0		0	0	0	12
Total contact hours	180				
Pre-requisites/Exposure	Practical exposure				
Co-requisites	--				

COURSE OBJECTIVES

The course will enable the student-teacher to:

The research project course aims to enhance students' research skills, critical thinking, and problem-solving abilities. It emphasizes effective communication of findings, ethical research practices, and independent learning. Students engage in in-depth literature reviews, data analysis, and interpretation, while contributing to knowledge within their field. The project prepares students for advanced studies or careers by fostering interdisciplinary learning and a deeper understanding of their chosen subject.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Recall research methodologies and ethical guidelines.

CO2: Comprehend existing literature and research gaps.

CO3: Apply data collection and analysis techniques**.**

CO4: Analyze findings to draw meaningful conclusions.

CO5: Evaluate research significance and ethical considerations.

CO6: Generate original insights, communicate effectively, and contribute to knowledge in the field.

CATALOG DESCRIPTION

1. Students will be divided among faculty members of the school for the supervision of the research work.

2. In the first week of Semester V, each faculty member will assign a suitable research topic to the students from the selected topics in the areas of chemical sciences.

3. The student will work on the assigned research topic during semesters V and VI in regular consultation with his/her assigned teacher.

4. The student will write a dissertation based on the research work carried out during Semesters V and VI and prepare two copies to be submitted to the office of the Dean duly signed by the student and the supervisor in the sixth week of VI semester or a date decided by the Dean of the School.

5. Before preparing power point presentation and submission of dissertation, each student has to deliver a seminar talk on his/ her research project work on a date fixed by Dean, necessary suggestions has to be incorporated in the final draft of dissertation.

6. The student will make a power point presentation based on the work carried out and mentioned in the dissertation to the board of examiners appointed by the University.

Assessment & Evaluation

Components	Quiz/Assignment/	Quiz/Assignment	Attendance	Mid Term Exam	End Term Exam
Weightage (%)	**20**	10	10	20	50

Programme and Course Mapping

Course Code	Course	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO10	PSO1	PSO2	PSO3	PSO4
SCCH402Research Project	**CO1**	2	2	1	3	1	2	2	1	1	1	3	2	1	2
	CO2	1	2	1	2	1	2	2	2	1	1	2	3	1	2
	CO3	2	2	2	2	2	3	1	2	2	2	1	1	2	2
	CO4	2	1	1	3	3	2	1	1	2	2	2	1	2	2
	CO5	2	2	1	2	1	2	1	1	1	1	2	1	2	
	CO6	1	3	1	2	1	2	2	3	2	3	2	1	3	

DISCIPLINE SPECIFIC ELECTIVE-I

SCCH304	**Medicinal Chemistry**	L	T	P	C
Version 1.0		4	0	0	4
Total Contact Hours	60				
Pre-requisites/Exposure	12th level Chemistry				
Co-requisites	--				

Course Objectives

Study of the topics included in this course will enable the students to

1. familiarize with the concept of Prodrug, drug and their classification.
2. build a basic knowledge of the theory of drug activity, bio-physical and chemical properties and structure activity relationship.
3. knowledge about some of the representative drugs and their mode of action.

Course Outcomes:

On completion of this course, the student-teacher will be able to:

CO1: recall and list the various bio-physicochemical properties of drugs, including acidity/basicity, solubility, ionization, hydrophobic/hydrophilic properties, and Lipinski Rule.

CO2: explain the concept of drug-like properties and their relevance to drug development.

CO3: **a**nalyze the 3D-structure of molecules by considering bond lengths, bond angles, and dihedral angles.

CO4: **a**nalyze the structural features of representative drug molecules like catecholamines and relate them to their biological effects.

Catalog Description

Medicinal chemistry is the discipline which involves intersection of synthetic organic chemistry, and pharmacology and various other biological specialties, where they are involved with design, chemical synthesis and development for market of pharmaceutical agents, or bio-active molecules (drugs).Medicines are required for treatment of different diseases and their action is dependent on their structure, stereochemistry, size and presence of different groups. This course provides an opportunity for understanding classification of drugs along with structure, mode of action and metabolism of some of the representative drugs. Biophysico-chemical properties of steroids, prostaglandins, enzyme, hormone and vitamins will also be discussed.

Course Content

UNIT I **15 Lecture**

Bio-physicochemical properties

Acidity/Basicity, Solubility, Ionization, Hydrophobic properties, Hydrophilic properties, Lipinski Rule, Drug-like properties, Understanding of the biological activity parameters such as K_i, K_d, LD_{50}, EC_{50}, IC_{50}, CC_{50}, ADMET properties

UNIT II **15 Lecture**

Structural properties

Isosterism, Bioisosterism, Nonclassical isosteres, Understanding of the 3D-structure along with bond length, bond angle and dihydral angle, Concept of Configuration and Conformation with examples, Concept of stereochemistry in terms of biological response with examples, Stereoselectivereceptorsorenzymessuchasmuscarinicreceptor,Stereochemicallypuredrugand recemates, Examples such as catecholamines,etc.

UNIT III **15 Lecture**

Drug target understanding

Metabolism, Drug metabolism, Anti-metabolite, Enzyme inhibitor, Agonist, Antagonist, Examples.

Medicinal Chemistry of Therapeutic Agent

Structure, Chemistry, Mode of action and adverse effect of the representative therapeutic agents suchasAnti-infectiveagent,Antimalarials,Antibacterial,Antiviral, Anticancer, CNS acting drugs, AdrenergicAgents,CholinergicDrugs,Diuretics,Cardivascular,localanestheticagent,Analgesic Agents, Histamine and Antihistamineagents

UNIT IV **15 Lecture**

Steroids, Prostaglandins, Enzyme, Hormone and Vitamins

Biophysico-chemical properties, Steroid Hormone Receptors, Chemical Contraceptive agents, COX-2 inhibitors, Prostaglandins for Ophthalmic use, pharmaceutically important enzyme products such as Pancreatin, Trypsin, Insulin. Classification of vitamins with examples.

Concept of rational drug design

Structureactivityrelationship,Drug-receptorunderstanding,Molecularmodeling,Structurebased drug design.QSAR.Applications of Artificial Intelligence in drug delivery and development.

Recommended books/References:

1. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical ...by Charles Owens Wilson, John H. Block, Ole Gisvold, John MarloweBeale
2. Foye's Principles of Medicinal Chemistry by David A. Williams, Thomas L. Lemke, William

O. Foye (2008), Kluwer publication.
3. Remington: The Science and Practice of Pharmacy Vol 1, Ed. 19 by Joseph Price Remington, Alfonso R. Gennaro. (1995), MACKPublishing.
4. Burgers Medicinal Chemistry by Manfred E. Wolff, AlfredBurger
5. Burgers Medicinal Chemistry and Drug Discovery by Abraham D. J., Lewis F. L., Burger A., vol.5, 6th Edn., 2003, HobokenN.J.Wiley,
6. The Organic Chemistry of Drug Design and Drug Action by Silverman R. B., 2ndEdn., Academic Press.2012.
7. Exploring QSAR: Fundamental and applications in Chemistry and Biology by Hansch C. and Leo, A American Chemical Society(1995)
8. Patrick, G. Medicinal Chemistry, Oxford.University Press(2000)

Open Educational Resources (OER)

- https://www.youtube.com/watch?v=YAMfmt03oU8
- https://www.youtube.com/watch?v=-VNOSGpdBW8
- https://www.iit.edu/academics/programs/medicinal-chemistry-bs
- http://www.chemguide.co.uk/physical/acidbaseeqia/definitions.html
- https://chem.libretexts.org/Courses/Pacific_University/Organic_Chemistry_with_a_Biological_Emphasis
- http://mccammon.ucsd.edu/teaching/medchem/
- https://www.bbau.ac.in/dept/Chemistry/TM/MCH%20402%20Medicinal%20Chemistry%20(Chapter%20I)%20DoC.pdf
- https://pharmaedu.in/medicinal-chemistry-1-notes-pdf/

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Quiz/Assignment/	Attendance	Mid Term Exam	End Term Exam
Weightage (%)	20	10	20	50

Course Code	Course	P	P	P	P	P	P	P	P	P	PO	PS	PS	PS	PS

and Title	Outcomes (COs)	O1	O2	O3	O4	O5	O6	O7	O8	O9	10	O1	O2	O3	O4
SCCH304 MEDICINAL CHEMISTRY	**CO1**	3	2	1	2	2	3	2	2	2	2	3	2	3	3
	CO2	1	2	2	1	1	1	1	2	1	1	2	2	2	2
	CO3	2	2	2	2	1	2	1	1	2	2	2	2	1	2
	CO4	2	3	1	3	1	1	2	2	1	2	1	1	2	2

1=weakly mapped

2= moderately mapped

3=strongly mapped

Unit I	Biophysico Chemical Properties
Local	-
Regional	-
National	-
Global	Biophysico Chemical Properties
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	Structural properties
Local	-
Regional	-
National	-
Global	Structural properties
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-

Unit III	Drug target understanding and Medicinal Chemistry of Therapeutic Agent
Local	-
Regional	-
National	-
Global	Drug target understanding and Medicinal Chemistry of Therapeutic Agent
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Steroids, Prostaglandins, Enzyme, Hormone and Vitamins; Concept of rational drug design
Local	-
Regional	-
National	-
Global	Steroids, Prostaglandins, Enzyme, Hormone and Vitamins; Concept of rational drug design
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Quality technical, vocational and tertiary education, including university (4.3); employment, decent jobs and entrepreneurship (4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India'sHigher Education System focussing on intellectual curiosity, scientific temper,(9.1); Focus on interdisciplinary skill 11.3: critical thinking and problem solving ability 11.2
POE/4th IR	Skill development through project work , team work ; Employability as chemist in pharmaceutical companies

Teaching Plan:

Weekly Teaching Plan	**Topic/Unit No.**	**Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]**	**Teaching-Learning Methods**
Week1	Introduction to Medicinal Chemistry	Foye's Principles of Medicinal Chemistry	Lecture, Discussion
Week 2	Drug Targets and Receptors	Wilson and Gisvold's Textbook of Organic Medicinal Chemistry	Lecture, Case Studies
Week 3	Bio-physicochemical Properties	Wilson and Gisvold's Textbook of Organic Medicinal Chemistry	Lecture, Interactive Demonstrations
Week 4	Structural Properties	Wilson and Gisvold's Textbook of Organic Medicinal Chemistry, ChemTube3D, Organic Chemistry	Lecture, 3D Models
Week 5	Drug Metabolism and Enzyme Inhibition	Remington: The Science and Practice of Pharmacy Vol 1	Lecture, Case Studies
Week 6	Introduction to Drug Design	The Organic Chemistry of Drug Design and Drug Action	Lecture, Group Activities
Week 7	QSAR and Molecular Modeling	Exploring QSAR: Fundamental and applications..., PhET Interactive Simulations, ChemCollective	Lecture, Computer Simulations
Week 8	Review and Midterm Examination	Patrick, G. Medicinal Chemistry	Review Session, Midterm Exam
Week 9	Anti-Infective Agents	Burgers Medicinal Chemistry and Drug Discovery	Lecture, Guest Speaker
Week 10	Anticancer and CNS-Acting Drugs	Patrick, G. Medicinal Chemistry	Lecture, Case Studies
Week 11	Cardiovascular and Diuretic Drugs	Burgers Medicinal Chemistry	Lecture, Interactive Discussions
Week 12	Local Anesthetics and Analgesics	Burgers Medicinal Chemistry	Lecture, Problem-Solving Sessions
Week 13	Medicinal Chemistry of Hormones	Foye's Principles of Medicinal Chemistry	Lecture, Concept Mapping

Week 14	Ethical Considerations and Review	Patrick, G. Medicinal Chemistry	Lecture, Group Discussions, Final Review

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning Outcomes (CLOs)	Teaching-Learning Activities (TLAs)	Assessment Tasks
I	• Understand bio-physicochemical properties of drugs, including acidity/basicity, solubility, ionization, etc. • Apply knowledge of drug-like properties and biological activity parameters	Lecture, Interactive Demonstrations, Case Studies, Group Activities, Guest Lectures, Field Trips	Quizzes, Class Discussions, Peer Assessment, Problem-Solving Exercises, Group Projects, Presentation, Reports, Participation
II	• Analyze isosterism and bioisosterism concepts. • Understand 3D-structures, configuration vs. conformation, and stereochemistry's impact on drug response.	Lecture, Interactive Discussions, 3D Models, Visualization Tools, Problem-Solving Sessions, Case Studies, Group Discussions	Concept Mapping, In-Class Activities, Model Building, In-Class Quizzes, Presentation, Group Assignments
III	• Define key terms related to drug metabolism and interactions. • Compare agonists and antagonists in terms of mechanism and examples. • Discuss the importance of ADMET properties and metabolism	Lecture, Interactive Demonstrations, Lab Practical, Role-Playing, Case Studies, Simulations, Guest Lectures, Panel Discussions, Field Trips	Quizzes, Lab Reports, Role-Playing Assessments, Case Analysis, Presentation, Reports, Participation
IV	• Analyze the biophysical-chemical properties of steroids and prostaglandins. • Understand the roles of enzymes, hormones, and vitamins in pharmacology. • Apply the principles of rational drug design	Lecture, Interactive Demonstrations, Lab Practical, Group Discussions, Case Studies, Research Assignments, Problem-Solving Sessions, Computer Simulations	Quizzes, Lab Reports, Presentations, Written Assignments, Model Building, In-Class Quizzes

SCCH356	Medicinal Chemistry Practicals	L	T	P	C

Version 1.0		0	0	4	2
Total Contact Hours	**30**				
Pre-requisites/Exposure	12th level Chemistry				
Co-requisites	--				

Course Objectives

In this course students will appreciate and comprehend the basic concepts regarding medicinal compounds, methods of synthesis of drugs, their importance for remediation and management of diseases.

Course Outcomes

On completion of this course, the student-teacher will be able to:

CO1: effectively apply the principles of fractional distillation and vacuum distillation to purify solvents.

CO2: analyze and compare thin-layer chromatography and column chromatography techniques.

CO3: evaluate the physicochemical properties of acid and basic salts of drugs

CO4: create and modify various organic compounds through different synthesis methods, including precipitation, recrystallization, and specific synthesis.

Catalog Description

Understanding of Medicinal Chemistry is very essential from the point of view of designing these molecules for various therapeutic applications. It is imperative that structure plays a very significant role in mitigating diseases. Through this course students will have experiential learning regarding purification and separation techniques, synthesis of various drug molecules, and understanding of biophysical properties of these compounds.

Course Content

Practical wok suggested:

1. Purification Techniques of solvents by Fractional Distillation and Vacuum Distillation.
2. Thin Layer Chromatography Technique and Purification of commercially available drugs/Synthesized Compounds by ColumnChromatography.
3. Preparation of Acid/Basic Salts of Drugs and Evaluation of their Physicochemical Properties.(Benzilic Acid & Sodium Benzoate)

4. Synthesis & Purification of following Compoundsusing

   i). precipitation or Recrystallization. ii) Synthesis of Benzimidazole.

   (iii)Synthesis of Anthranilic Acid.(iv)Synthesis of Sulphanilamide.

   (v)Synthesis of benzoic acid from benzyl alcohol.(vi)Synthesis of 1,4 – dihydropyridine.

5. Computational modeling of drug design/use of softwares may be demonstrated tostudents
6. To perform Assay of aspirin..

Suggested books/references:

1. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J. D.Barnes, M. J. K Thomas, 6th Edition, Pearson's Education Ltd.
2. Advanced Practical Medicinal Chemistry, Ashutosh Kar, New Age International Ltd. (2004).
3. Vogel"s Textbook of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford ,P.W.G. Smith, A. R Tatchell, 5th edition (2008), Pearson's Education Ltd

(The list of experiments and books are purly suggestive; University/institute may incorporate further changes in number of experiments and books/refererences (updated version from time to time) based on course design and available infrastructure facilities).

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Open Educational Resources (OER)

- https://pharmacyinfoline.com/bp406p-medicinal-chemistry-i-practical/
- https://www.miperknlapindia.ac.in/BP406P-medicinal-chemistry1.pdf
- https://www.ipinnovative.com/media/open-access-books/Practical_Lab_Manual_of_Pharmaceutical_Organic_Chemistry_-1_Low.pdf
- https://www.youtube.com/watch?v=D7KrySEKoJI
- https://www.youtube.com/watch?v=lUxkcEoGkVg
- https://www.youtube.com/watch?v=KPnmdwj3SRI
- http://chemcollective.org/
- https://www.khanacademy.org/science/chemistry

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Components	Conduct of Experiment	Lab Record/ Quizzes/ Viva-voice	Attendance	End Term
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course Code	Course	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PS	PS	PS	PS
SCCH356 MEDICINAL CHEMISTRY PRACTICALS	**CO1**	**3**	**1**	**1**	**1**	**1**	**2**	**2**	**1**	**2**	**2**	**3**	**1**	**2**	**1**
	CO2	**2**	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**1**
	CO3	**1**	**1**	**2**	**1**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**1**	**1**
	CO4	**1**	**1**	**1**	**3**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**3**	**2**	**2**

1=weakly mapped

2= moderately mapped

3=strongly mapped

Unit I	1. Purification Techniques of solvents by Fractional Distillation and Vacuum Distillation. 2. Thin Layer Chromatography Technique and Purification of commercially available drugs/Synthesized Compounds by Column Chromatography. 3.Preparation of Acid/Basic Salts of Drugs 4. Synthesis & Purification Compounds 5.Computational modelling of drug design/use of software's may be demonstrated to set
Local	-
Regional	-
National	-
Global	Purification Techniques, Thin Layer Chromatography Technique, Preparation of Acid/Basic Salts of Drugs and Evaluation of their Physicochemical Properties.
Employability	-
Entrepreneurship	-
Skill Development	Hand on Preparation of Acid/Basic Salts of Drugs and Evaluation of their Physicochemical Properties. (Benzilic Acid & Sodium Benzoate) 4. Synthesis & Purification of following Compounds using i). precipitation or Recrystallization. ii) Synthesis of Benzimidazole. (iii)Synthesis of Anthranilic Acid.

	(iv)Synthesis of Sulphanilamide. (v)Synthesis of benzoic acid from benzyl alcohol. (vi)Synthesis of 1, 4 – dihydropyridine. 5.Computational modelling of drug design/use of software's may be demonstrated to set
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Quality Tertiary Education (4.3); Employability Skill (4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India'sHigher Education System through scientific temper (9.1.1).
POE/4th IR	Employability & Skill development through Practicals for placement in Pharmaceutical companies; Team work/Employability & Skill development through Practicals

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Methods
Week 1	Introduction to Course, Safety Measures	Lecture notes	Lecture, Discussion
Week 2	Purification Techniques - Overview	Vogel's Textbook of Practical Organic Chemistry	Lecture, Lab Demonstration
Week 3	Fractional Distillation	Vogel's Textbook of Practical Organic Chemistry, ChemCollective	Lecture, Lab Demonstration, Practice
Week 4	Vacuum Distillation	Vogel's Textbook of Practical Organic Chemistry	Lecture, Lab Demonstration, Practice
Week 5	Thin Layer Chromatography (TLC)	Vogel's Textbook of Practical Organic Chemistry, ChemTube3D	Lecture, Lab Demonstration, Practice
Week 6	Column Chromatography	Vogel's Textbook of Practical Organic Chemistry, PhET Simulations	Lecture, Lab Demonstration, Practice
Week 7	Acid/Base Salts Preparation	Vogel's Textbook of Practical Organic Chemistry	Lecture, Lab Demonstration, Practice
Week 8	Physicochemical Properties Evaluation	Vogel's Textbook of Practical Organic Chemistry	Lecture, Lab Demonstration, Discussion

Week 9	Precipitation and Recrystallization	Vogel's Textbook of Practical Organic Chemistry, Virtual Chemistry Experiments	Lecture, Lab Demonstration, Practice
Week 10	Synthesis of Benzimidazole	Vogel's Textbook of Practical Organic Chemistry, YouTube - Tyler DeWitt	Lecture, Lab Demonstration, Practice
Week 11	Synthesis of Anthranilic Acid	Vogel's Textbook of Practical Organic Chemistry	Lecture, Lab Demonstration, Practice
Week 12	Synthesis of Sulphanilamide	Vogel's Textbook of Practical Organic Chemistry	Lecture, Lab Demonstration, Practice
Week 13	Synthesis of Other Compounds	Vogel's Textbook of Practical Organic Chemistry, Chemguide	Lecture, Lab Demonstration, Practice
Week 14	Computational Drug Design	Khan Academy - Chemistry, Research Papers	Lecture, Discussion, Case Studies

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning Outcomes (CLOs)	Teaching-Learning Activities (TLAs)	Assessment Task Methods
I	Understand the basics of purification techniques Demonstrate knowledge of safety measures in the lab Identify and explain the importance of analytical chemistry	Lecture on the principles of purification techniques Lab demonstration of safety protocols and lab equipment Discussion on the role of analytical chemistry in various fields	Class quiz on purification concepts Lab safety assessment Written assignment on analytical chemistry
II	Explain fractional distillation and vacuum distillation Apply theoretical concepts in practical settings Analyze experimental results and observations	Lecture on fractional and vacuum distillation processes Lab session performing fractional and vacuum distillation Group discussion on the obtained results and observations	Lab practical on distillation techniques Lab report evaluation Group presentation of experimental analysis

III	Describe Thin Layer Chromatography (TLC) technique Perform TLC experiments and interpret results Discuss the importance of chromatographic techniques	Lecture on principles and applications of Thin Layer Chromatography Lab session conducting TLC experiments and analyzing results Group discussion on the significance of chromatography methods	TLC practical and interpretation Lab report and analysis evaluation Class discussion and participation
IV	• Understand Column Chromatography technique • Apply chromatography for compound separation • Analyze chromatographic data and draw conclusions	• Lecture on principles and applications of Column Chromatography • Lab session performing Column Chromatography experiments • Group analysis of chromatographic data and	• Lab practical on Column Chromatography • Lab report evaluation • Group presentation and data analysis

SCCH306	**Heterocyclic Chemistry**	L	T	P	C
Version 1.0		3	1	0	4
Total Contact Hours	**60**				
Pre-requisites/Exposure	Basics of organic chemistry				
Co-requisites	--				

Course Objectives

1. To enable the students to understand Heterocyclic compounds and their reactions.
2. To enable the student to differentiate between two, three, four and five membered heterocyclic compounds with respect to the properties.

Course Outcomes

On completion of this course, the student-teacher will be able to:

CO1: recall the chemistry of three-membered rings with one heteroatom and four-membered heterocycles including their synthetic approaches, reactivity's, and natural product synthesis.

CO2: explain the principles behind the synthetic approaches and reactivities of three-membered rings with one heteroatom and four-membered heterocycles.

CO3: apply the knowledge of synthetic strategies and reactivities to propose and predict chemical transformations involving various heterocycles with different heteroatoms.

CO4: evaluate the factors influencing reactivity and selectivity in heterocyclic chemistry.

Course Content

UNIT I

HeterocyclicChemistry **15 Lectures**

Three-membered rings with one heteroatom: Chemistry of oxiranes, aziridines and episulphides - synthetic approaches and reactivities.

UNIT II **15 Lectures**

Three-membered heterocycles with two heteroatoms: oxaziranes, diaziridines and diazirines - synthetic approaches and reactivities.

UNIT III **15 Lectures**

Four-membered heterocycles: oxitanes, azatidanes and thietanes - synthetic approaches and reactivities. natural products:synthesis of Peniciline andcephalosporine.

UNIT IV **15 Lectures**

Five-membered aromatic heterocycles:

1. With one heteroatom: furans, pyrroles and thiophenes - general synthetic approaches, properties andreactivities.
2. With two heteroatoms: oxazoles, isoxazoles, imidazoles, thiazoles, pyrazoles and isothiazoles - general synthetic approaches andreactivities.
3. With three and four heteroatoms: triazoles and tetrazoles - synthetic approaches, properties andreactivity.

Condensed five-memberedHeterocycles:

Benzofuran, indoles and benzothiazoles - general synthetic approaches, with greater emphasis on the chemistry ofIndoles.

Recommended Books/references:

1. Heterocyclic Chemistry, J.A. Joule, K. Mills, Wiley,2010.
2. The Essence of heterocyclic Chemistry, A. R. Parikh, H. Parikh, R. Khunt, New Age Int. Publication,
3. Principles of Modern Heterocyclic Chemistry, L. A. Paquette, W. A. Benjamin, New York,1968.
4. Heterocyclic Chemistry, J.A. Joule and G. F. Smith, van Nostrand, London,1978.
5. Comprehensive Heterocyclic Chemistry. The structure, reactions, synthesis and use of Heterocyclic compounds, (Ed. A.R. Katritzky and C. W. Rees),. Vol 1-8, Pergamon Press,1984.
6. Handbook of Heterocyclic Chemistry, A. R. Katritzky, Pergamon Press,1985.
7. Van der plas, H. C. Ring transformations of Heterocycles, Vols 1 and 2, Academic Press, 1974.

Open Educational Resources (OER)

- https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/heterocy.htm
- https://www.youtube.com/watch?v=zyRRHfH9_Zg
- https://www.youtube.com/watch?v=089fZfDTrEs
- https://www.khanacademy.org/science/organic-chemistry
- http://www.rsc.org/learn-chemistry
- http://chemcollective.org/
- https://www.youtube.com/watch?v=LVGmOoPH10M

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Quiz/Assignment Presentation/ Assignment/ etc.	Attendance	Mid Term Exam	End Term Exam
Weightage (%)	20	10	20	50

Programme and Course Mapping

Course Code and Title	Course Outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SCCH306 HETREOCYCLIC CHEMISTRY	CO1	3	2	1	2	1	2	1	2	2	2	3	3	2	2
	CO2	2	2	1	2	1	2	1	2	2	2	3	3	2	2
	CO3	3	2	2	2	1	2	1	2	2	2	3	3	2	2
	CO4	2	2	2	2	1	2	1	2	2	2	3	3	2	2

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	HeterocyclicChemistry
Local	-
Regional	-
National	-
Global	The study of Heterocyclic Chemistry has a global relevance as it contributes to the development of new drugs, which can address global health challenges and improve healthcare worldwide.

Employability	Knowledge of Heterocyclic Chemistry enhances employability in various industries, including pharmaceuticals, chemical research, drug discovery, and development, where the design and synthesis of heterocyclic compounds are crucial.
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	Three-membered heterocyclic
Local	-
Regional	-
National	-
Global	The study of Heterocyclic Chemistry has a global relevance as it contributes to the development of new drugs, which can address global health challenges and improve healthcare worldwide.
Employability	Knowledge of Heterocyclic Chemistry enhances employability in various industries, including pharmaceuticals, chemical research, drug discovery, and development, where the design and synthesis of heterocyclic compounds are crucial.
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Four-membered heterocycles
Local	-
Regional	-
National	-
Global	The study of Heterocyclic Chemistry has a global relevance as it contributes to the development of new drugs, which can address global health challenges and improve healthcare worldwide.
Employability	Knowledge of Heterocyclic Chemistry enhances employability in various industries, including pharmaceuticals, chemical research, drug discovery, and development, where the design and synthesis of heterocyclic compounds are crucial.
Entrepreneurship	-

Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Five -membered heterocycles
Local	-
Regional	-
National	-
Global	The study of Heterocyclic Chemistry has a global relevance as it contributes to the development of new drugs, which can address global health challenges and improve healthcare worldwide.
Employability	Knowledge of Heterocyclic Chemistry enhances employability in various industries, including pharmaceuticals, chemical research, drug discovery, and development, where the design and synthesis of heterocyclic compounds are crucial.
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment &Sustainability	-
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education 11.1- 11.13)
POE/4th IR	Heterocyclic Chemistry plays a significant role in the 4th IR by contributing to the development of advanced materials, drug discovery, and precision medicine, which are essential components of the technological advancements in this era.

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open	Teaching-Learning Method

Week 1	Introduction to Heterocyclic Chemistry Three-membered rings with one heteroatom	- Joule and Mills (Ch. 1) - Joule and Mills (Ch. 2)	Lectures, Discussion Lectures, Visual
Week 2	Chemistry of oxiranes, aziridines, episulphides Synthetic approaches and reactivities	- Joule and Mills (Ch. 3) - ChemCollective	Lectures, Case Studies
Week 3	Three-membered heterocycles with two heteroatoms Oxaziranes, diaziridines	- Joule and Mills (Ch. 4) - Khan Academy: Organic Chemistry	Lectures, Group Activities
Week 4	Four-membered heterocycles Oxetanes, azetidines, thietanes	- Paquette (Ch. 1) - Virtual Textbook of Organic Chemistry	Lectures, Interactive Demos
Week 5	Natural product synthesis: Penicillin, Cephalosporin	- Joule and Mills (Ch. 5)	Lectures, Case Studies
Week 6	Five-membered aromatic heterocycles With one heteroatom: furans, pyrroles	- Joule and Mills (Ch. 6) - ChemTube3D	Lectures, Visual Aids
Week 7	With two heteroatoms: oxazoles, isoxazoles, imidazoles, thiazoles, pyrazoles, isothiazoles	- Organic Chemistry Portal	Lectures, Group Activities
Week 8	With three and four heteroatoms: triazoles, tetrazoles	- RSC Learn Chemistry	Lectures, Interactive Demos
Week 9	Overview and Recap	- Joule and Mills (Ch. 7)	Lectures, Discussion
Week 10	Application of Heterocyclic Chemistry	- Paquette (Ch. 2)	Lectures, Case Studies
Week 11	Problem Solving Session	- Katritzky (Handbook)	Problem-Solving Workshops
Week 12	Practical Aspects of Heterocyclic Chemistry	- Joule and Mills (Ch. 8)	Practical Sessions, Demos
Week 13	Emerging Trends in Heterocyclic Chemistry	- Research articles, open educational resources	Seminars, Guest Lectures
Week 14	Review and Assessment	- Various textbooks, open education resources	Review, Assessment, Q&A Session

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching-Learning Activities	Assessment Task Methods
I	• Understand the chemistry of three-membered rings with one heteroatom (oxiranes, aziridines, episulphides) and their synthetic approaches and reactivities. • Apply the principles of synthetic strategies and reactivities to predict and propose chemical transformations	• Lectures - Visual Aids - Group Discussions • Problem-Solving Exercises - Case Studies • Interactive Demonstrations - Group Activities • Laboratory Sessions (if applicable)	• Quizzes - In-class Participation • Homework Assignments - Peer Assessments • Class Tests - Concept Mapping • Practical Assessments (if applicable)
II	• Explain the chemistry and reactivity of three-membered heterocycles containing two heteroatoms (oxaziranes, diaziridines, diazirines). • Demonstrate an understanding of the synthetic approaches used in the preparation of these heterocycles. • Apply the knowledge of reactivity patterns to predict and propose transformations involving these heterocycles.	• Lectures - Visual Aids - Discussion • Problem-Solving Exercises - Case Studies • Interactive Demonstrations - Group Activities	• Quizzes - In-class Participation • Homework Assignments - Peer Assessments • Class Tests - Concept Mapping

SCCH358	**Heterocyclic Chemistry Practicals**	L	T	P	C
Version 1.0		0	0	4	2
Total contact hours	30				
Pre-requisites/Exposure	Basics of organic compounds				
Co-requisites	--				

Course Objectives

- Recall and describe the methods used for the identification of hetero atoms (S, N, X) in organic compounds.
- Explain the principles and techniques of column chromatography and thin-layer chromatography (TLC) for the identification and separation of simple organic compounds containing hetero atoms.
- Recognize and interpret spectroscopic data (spectra) to identify simple organic compounds and determine their melting point/boiling point for purity assessment.
- Apply the concepts of aldol condensation reaction to synthesize indigo from 2-nitrobenzaldehyde and acetone under basic conditions.
- Utilize column chromatography and TLC techniques to separate and analyze mixtures of simple organic compounds containing hetero atoms.

Course Outcomes

On completion of this course, the students will be able to

CO1: Demonstrate understanding of organic compound analysis by identifying hetero atoms (S, N, X) using laboratory techniques and explaining the principles of column chromatography and TLC for separating heteroatom-containing compounds.

CO2:Apply spectroscopic methods to identify simple organic compounds, analyze spectral data for identification, and assess compound purity through melting point/boiling point determination.

CO3:Apply aldol condensation reaction principles to synthesize indigo, design and perform experiments for identifying and separating heteroatom-containing organic compounds, and evaluate the success of indigo synthesis based on spectroscopic and purity assessment.

CO4: Analyze experimental outcomes, compare spectroscopic results with known spectra, evaluate the effectiveness of separation techniques, and critically assess the synthesis of indigo in terms of purity and reaction yield.

Catalog Description

In this course Identification of hetero atoms, Identification/separation of simple organic compounds containing hetero atoms using column chromatorgapy/TLC, Spectroscopic identification of simple organic compounds and preparation of Indigo dye, are available.

Course Content

List of suggested laboratory experiments

1. Identification of hetero atoms (S, N, X) in given organic compounds inlab.
2. Identification/separation of simple organic compounds containing hetero atoms using column chromatorgapy/TLC) inlab.

3. Spectroscopic identification of simple organic compounds (spectra may be provided to the students and teachers may help the students to identify the compounds using spectra). Melting point/boiling point of the compounds may be checked for itspurity.
4. Teacher may guide the students for preparation of : Indigo (using aldol condensation reaction of 2-nitrobenzaldehyde with acetone in basiccondition);

(Depending upon laboratory facilities, more preparation of heterocyclic group of compoundsmay be incorporated byteacher).

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.

Open Educational Resources:

https://youtu.be/w5A0mqVEYBI
https://www.ox.ac.uk/admissions/undergraduate/courses/course-listing/chemistry
https://www.exeter.ac.uk/undergraduate/courses/biosciences/biomed/
https://www.ox.ac.uk/admissions/undergraduate/courses/course-listing/chemistry
https://www.manchester.ac.uk/study/undergraduate/courses/2024/09453/mchem-chemistry-with-international-study/all-content/
https://www.qub.ac.uk/courses/undergraduate/biochemistry-bsc-c700/
https://byjus.com/chemistry/classification-organic-compounds/
https://www.qub.ac.uk/courses/undergraduate/medicinal-chemistry-bsc-f154/
Heterocycles Part 1: Furan, Thiophene, and Pyrrole
Pyrones (6 membered Heterocyclic compounds) Synthesis & Reaction #mscchemistrynotes #heterocyclic
https://www.youtube.com/watch?v=jScWkQEkpsI

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	**Conduct of**	**Lab**	**Attendance**	**End Term Practical**
Weightage	**20**	**20**	**10**	**50**

Programme and Course Mapping

Course code and title	**COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
SCCH358 HETREOCYCLIC	CO1	**2**	**1**	**1**	**3**	**1**	**1**	**1**	**1**	**1**	**2**	**3**	**1**	**1**	**1**
	C	**2**	**3**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**1**	**1**

CHEMISTRY PRACTICALS	**O2**														
	CO3	**1**	**1**	**3**	**2**	**1**	**2**	**1**	**1**	**1**	**1**	**2**	**1**	**3**	**1**
	CO4	**2**	**1**	**1**	**2**	**1**	**2**	**1**	**1**	**1**	**1**	**2**	**1**	**2**	**3**

Unit	Identification of hetero atoms, Identification/separation of simple organic compounds containing hetero atoms using column chromatography/TLC, Spectroscopic identification of simple organic compounds and preparation of Indigo dye, are available.
Local	-
Regional	-
National	-
Global	The study of Heterocyclic Chemistry has global relevance as it provides fundamental knowledge and skills for drug discovery and development, which can address global health challenges and improve healthcare worldwide.
Employability	Knowledge and skills in the identification and analysis of organic compounds containing hetero atoms are highly valued in industries such as pharmaceuticals, chemical research, quality control, and forensic science, enhancing employability prospects.
Entrepreneurship	-
Skill Development	The topics covered in the syllabus promote various skills such as laboratory techniques, column chromatography, thin-layer chromatography, spectroscopic analysis, and critical thinking, which are valuable for skill development in scientific research and analysis.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	The knowledge gained from the analysis of organic compounds can contribute to environmental studies, particularly in analyzing organic pollutants or monitoring chemical processes that impact the environment.
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13)Optimal Learning Environments and Support for Students (12.1-12.10)
POE/4th IR	The identification, separation, and spectroscopic analysis of organic compounds containing hetero atoms are essential skills in the 4th IR, particularly in the fields of drug discovery, materials science, and advanced manufacturing.

Teaching Plan:

Week	Practical Title	Textbook [TB]/Reference Book [RB]	Teaching-Learning Method
1	Identification of Heteroatoms	Organic Chemistry Textbook	Lecture, Discussion, Lab Demonstration
2	Identification of Heteroatoms (Continued)	Organic Chemistry Textbook	Hands-on Experiment
3	Separation of Compounds using Column Chromatography/TLC	Organic Chemistry Textbook	Lecture, Discussion, Lab Demonstration
4	Separation of Compounds (Continued)	Organic Chemistry Textbook	Hands-on Experiment
5	Spectroscopic Identification of Organic Compounds	Organic Chemistry Textbook, Spectroscopy References	Lecture, Lab Demonstration
6	Spectroscopic Identification (Continued)	Organic Chemistry Textbook, Spectroscopy References	Hands-on Experiment
7	Melting Point and Boiling Point Determination	Organic Chemistry Textbook	Lecture, Lab Demonstration
8	Melting Point and Boiling Point (Continued)	Organic Chemistry Textbook	Hands-on Experiment
9	Preparation of Indigo	Organic Chemistry Textbook	Lecture, Discussion, Lab Demonstration
10	Preparation of Indigo (Continued)	Organic Chemistry Textbook	Hands-on Experiment
11	Exploration of Heterocyclic Compounds	Organic Chemistry Textbook	Lecture, Discussion, Lab Demonstration
12	Exploration of Heterocyclic Compounds (Continued)	Organic Chemistry Textbook	Hands-on Experiment
13	Advanced Heterocyclic Compound Preparation	Organic Chemistry Textbook	Lecture, Discussion, Lab Demonstration
14	Advanced Heterocyclic Compound Preparation (Continued)	Organic Chemistry Textbook	Hands-on Experiment

Facilitating the Course learning Outcomes:

Unit No.	Course Learning Outcomes	Teaching-Learning Activities (TLAs)	Assessment Task Methods
Unit 1	Identify hetero atoms (S, N, X) in organic compounds.	Laboratory demonstration, guided experimentation.	Practical assessments, observation.
Unit 2	Separate organic compounds containing hetero atoms using column chromatography/TLC.	Hands-on experimentation, step-by-step guidance.	Practical assessments, separation efficiency.
Unit 3	Spectroscopically identify organic compounds using provided spectra.	Spectral analysis practice, guided interpretation.	Identification accuracy, practical assessments.
Unit 4	Measure melting point/boiling point for compound purity.	Hands-on melting/boiling point determination.	Accuracy of measurements, practical assessments.

SCCH308	**Introduction of Nanochemistry and Applications**	L	T	P	C
Version 1.0		3	1	0	4
Total Contact hours	**60**				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

Course Objectives

1. To be able to understand different classifications of nanomaterials.
2. To learn the experimental methods for synthesising nanomaterials.
3. To understand characterisation techniques that can be employed to study nano dimension.
4. To develop a comprehensive knowledge about size dependent properties of nanoparticles.

Course Outcomes

On completion of this course, the students will be able to

CO1: Demonstrate a basic understanding of nanoscience, nanostructures, and nanotechnology, including the classification of nano-materials and the calculation of surface atom percentage and surface-to-volume ratio for different nanoparticle shapes.
CO2: Able to comprehend the size-dependent properties of nanomaterials, such as quantum confinement, electrical, optical, magnetic, thermal, and catalytic properties, with examples of blue shift, red shift, and surface plasmon resonance.
CO3: Apply their knowledge of synthesis techniques, including top-down and bottom-up approaches, self-assembly methods, and solvo thermal processes, to prepare gold and silver nanoparticles, carbon nanotubes, and inorganic nanowires.
CO4: Analyze and interpret material characterization techniques, such as electron microscopy, diffraction, photoelectron spectroscopy, and zeta-potential measurement, to study nanomaterials' properties.

Catalog Description

This course imparts the basic concepts of nanotechnology. It enables the students to understand the idea of synthesis and structural aspects of different types of nanomaterials. The course of nanochemistry will impart the knowledge about different characterisation techniques for nanomaterials. The course also introduces the use of nanoparticles in environmental remediation and biology.

Course Content

Unit I: 15 Lectures

Introduction to nanoscience, nanostructure and nanotechnology (basic idea), Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures -Spheroid, Wire, Rod, Tube, and Quantum Dot); Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.

Unit II: 15 Lectures

Size dependent properties of nanomaterials (basic idea with few examples only): Quantum confinement, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blue shift & Red shift), Magnetic, thermal and catalytic properties.

Unit III: **15 Lectures**

Synthesis of Nanomaterials: Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures- control of nanoarchitecture- one dimensional control. Carbon nanotubes and inorganic nanowires.

Unit IV: **15 Lectures**

Material characterization techniques (basic idea of use of following instruments in nanomaterialcharacterizationneedtobeemphasized):Electronmicroscopictechnique,diffraction technique, photoelectron spectroscopy, zeta-potential measurement; Examples of use of nanomaterials in environmental remediation and biology (few practical examples of use of materials can bediscussed).

Text Books

1. C.N.R.Rao,A.Muller,A.K.Cheetam,TheChemistryofNanomaterials:Synthesis,Properties and Applications, Willey-VCH Verlag, Germany,2005.
2. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, London, 2004

Reference Books/Materials

1. R. W. Kelsall, I. W. Hameley, M. Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, England, 2005
2. CharlesP.PooleandFrankJOwens,*Introductiontonanotechnology*,WileyInterscience,2003.
3. Pradeep, T., A text of book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi,2012.

Open Educational Resources:

NanoHub: https://nanohub.org/
National Nanotechnology Initiative: https://www.nano.gov/
Nanowerk: https://www.nanowerk.com/
Nanoscience and Nanotechnology: https://ocw.mit.edu/courses/nanotechnology/
Nanotechnology Courses: https://www.coursera.org/courses?query=nanotechnology
YouTubeNanotechnology Explained: https://www.youtube.com/results?search_query=nanotechnology+explained
Nano.gov - Education Resources: https://www.nano.gov/nanotech-101/education
National Center for Biotechnology Information (NCBI) - Nanotechnology: https://www.ncbi.nlm.nih.gov/pmc/?term=nanotechnology
Nanoscience and Nanotechnology: https://www.khanacademy.org/science/nanoscience
Nanotechnology Publications: https://www.researchgate.net/search?q=nanotechnology

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz/Assignment/Presentation/ Assignment / etc.	Attendance	Mid Term Exam	End Term Exam
Weightage (%)	20	10	20	50

Programme and Course Mapping

Course code and Title	CourseOutcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SCCH308 Introduction to nanochemistry and applications	CO1	3	2	1	2	1	2	2	1	1	2	2	1	2	1
	CO2	3	3	2	2	1	2	1	1	2	1	1	2	2	1
	CO3	2	2	2	3	1	2	1	1	2	2	3	2	2	2
	CO4	2	2	1	3	1	2	2	1	1	1	1	3	1	2

Unit I	Introduction to Nano science, nanostructure and nanotechnology
Local	-
Regional	-
National	-
Global	Concepts of nanotechnology
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment &	Concepts of environment which enable student to solve basic problems related to

Sustainability	their surroundings.
Unit II	Hydrosphere
Local	-
Regional	-
National	-
Global	Hydrological cycle, aquatic pollution and water quality parameters
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit III	Size dependent properties of nanomaterial's
Local	-
Regional	-
National	-
Global	Synthesis and structural aspects of different types of nanomaterial's.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit IV	Material characterization techniques
Local	-
Regional	-
National	-
Global	The course of Nano chemistry will impart the knowledge about different characterization techniques for nanomaterials.
Employability	-
Entrepreneurship	-
Skill	-

Development	
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
SDG	Acquire theknowledge and skills needed to promotesustainable development,
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Technical Skills that match Industry Needs

Teaching Plan:

Weekly teaching plan	Topic / Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Method
1	I	TB: Ch. 1, Pg. 1-10	OER: Nanoscience Basics
2	I	TB: Ch. 1, Pg. 21-28	Problem-solving exercises
3	II	TB: Ch. 2, Pg. 45-54	OER: Nanomaterials
4	II	TB: Ch. 2, Pg. 61-68	OER: Electrical Properties
5	III	TB: Ch. 3, Pg. 85-92	OER: Nanomaterial Synthesis
6	III	TB: Ch. 3, Pg. 101-108	OER: Solvothermal Process
7	III	TB: Ch. 3, Pg. 117-124	Group discussion
8	III	TB: Ch. 4, Pg. 143-150	OER: Carbon Nanotubes
9	IV	TB: Ch. 5, Pg. 169-176	Instrument demos
10	IV	TB: Ch. 5, Pg. 183-190	OER: Diffraction Techniques
11	IV	TB: Ch. 5, Pg. 191-198	Problem-solving exercises
12	IV	TB: Ch. 5, Pg. 199-204	Lab practice
13	IV	TB: Ch. 6, Pg. 221-228	Case studies
14	Revision		Review assessment

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activities	Assessment Task Methods

1	Understand Introduction to Nanoscience and Nanostructures	Lectures on nanoscience, nanostructures, and classification of nano-materials.	Quiz on nanoscience and nanostructures concepts
2	Calculate Surface Atom Percentage and Surface-to-Volume Ratio	Problem-solving sessions on surface atom percentage and surface-to-volume ratio calculations.	Homework assignments and class discussions
3	Comprehend Size-Dependent Properties of Nanomaterials		

SCCH360	**Introduction of Nanochemistry and Applications Practicals**	L	T	P	C
Version 1.0		0	0	4	2
Total Contact hours	30				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

Course Objectives

1. To be familiarized with common instruments and glassware used in nanoparticles synthesis.
2. To fabricate zinc oxide and silver nanoparticles.
3. To confirm the successful synthesis of the mentioned particles with the help of absorbance values.
4. To learn and verify Beer-Lambert law.

Course Outcomes

On completion of this course, the students will be able to

CO1: Recall fundamental principles of nanoparticle synthesis and characterization.

CO2: Explain the application of Beer-Lambert law using nano-particles and understand the concept of bimetallic nanoparticles.

CO3: Apply synthesis techniques to create diverse nanoparticles and utilize them for characterization and property studies.

CO4: Analyze and interpret experimental data to assess the validity of Beer-Lambert law and draw conclusions about nanoparticle properties.

Catalog Description

This course imparts the basic understanding of nanoparticles synthesis. It enables the students to synthesise nanoparticles like zinc oxide and silver nanoparticles. The course also introduces the Beer-Lambert law, and its verification with the help of either a colorimeter or a UV spectrophotometer.

Course Content

List of Experiments

1. Synthesis of ZnO nanoparticles.
2. Preparation of Silvernanoparticles.

(diverse nanoparticles can be prepared by various routes)

3. Verification of Beer-Lambert law using nano-particles (above prepared nano-particles may be used for thestudy).(Dependinguponthe availabilityofinfrastructurefacilities,instructormayencouragethe students topreparebimetallicnano-particles,etc.andcharacterizedthem,studytheirvariouspropertieslike magnetism, adsorption,etc.)

Recommended/Reference Books

1. Pradeep T., A text book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012 edition.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Conduct of Experiment	Lab Record/Quizzes/ Viva-Voce	Attendance	End Term Practical Examination
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course	Course	PO	PO	PO	PO	PO	PO	PO	PO	PO	P	PSO	PSO	PSO	PSO

code and title	Outcome	1	2	3	4	5	6	7	8	9	O 10	1	2	3	4
SCCH360 Introduction of Nanochemistry and Applications Practicals	CO1	3	2	1	2	1	2	2	1	1	2	2	1	2	1
	CO2	3	3	2	2	1	2	1	1	2	1	1	2	2	1
	CO3	2	2	2	3	1	2	1	1	2	2	3	2	2	2
	CO4	2	2	1	3	1	2	2	1	1	1	1	3	1	2

Unit	This course imparts the basic understanding of nanoparticles synthesis. It enables the students to synthesise nanoparticles like zinc oxide and silver nanoparticles. The course also introduces the Beer-Lambert law, and its verification with the help of either a colorimeter or a UV spectrophotometer.
Local	-
Regional	-
National	-
Global	Basic understanding of nanoparticles synthesis. It enables the students to synthesize nanoparticles like zinc oxide and silver nanoparticles
Employability	Student centric methods, such as experiential learning, participative learningand problem-solving methodologies (2.3.1)
Entrepreneurship	Entrepreneurship; Team work/ Creativity by designing research problem
Skill Development	Disciplinary knowledge; Research related skills; scientific skills,
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
SDG	Skills for Decent Work (SDG 4.4), Sustainable Development and Global Citizenship (SDG 4.7), Ensure availability and sustainable management of water and sanitation for all (SDG 6); Promote peaceful and inclusive societies for sustainable development
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13), Promoting High Quality Research (18.1-18.9); Technology use and integration
POE/4th IR	Technical Skills that match Industry Needs;Focus on Employability Skills (Local/Regional and Global)Team Work, Technology Use and Integration (23.1-23.13), Internship Program; Consulting Field Projects

Teaching Plan:

Weekly Teaching plan	Practical/Topic	Activities and Procedures	Resources/ Teaching-Learning Method
Week 1	Synthesis of ZnO Nanoparticles	Introduction to ZnO nanoparticles synthesis, safety guidelines.	Lab Manual, Safety Guidelines
Week 2	Synthesis of ZnO Nanoparticles	Step-by-step procedure, chemical reactions, preparation of reagents.	Lab Manual, Reagents
Week 3	Preparation of Silver Nanoparticles	Introduction to silver nanoparticles synthesis, safety precautions.	Lab Manual, Safety Guidelines
Week 4	Preparation of Silver Nanoparticles	Detailed procedure, chemical reactions, handling of nanoparticles.	Lab Manual, Reagents
Week 5	Diverse Nanoparticles Synthesis (Route 1)	Introduction to diverse nanoparticles, selection of route.	Lab Manual
Week 6	Diverse Nanoparticles Synthesis (Route 1)	Step-by-step procedure, variations in synthesis parameters.	Lab Manual, Reagents
Week 7	Diverse Nanoparticles Synthesis (Route 2)	Introduction to another synthesis route, comparison with Route 1.	Lab Manual
Week 8	Diverse Nanoparticles Synthesis (Route 2)	Procedure, observations, analysis of results.	Lab Manual, Reagents
Week 9	Verification of Beer-Lambert Law	Introduction to Beer-Lambert Law, preparation of nano-samples.	Lab Manual
Week 10	Verification of Beer-Lambert Law	Spectrophotometric measurements, data collection and analysis.	Lab Manual, Spectrophotometer
Week 11	Bimetallic Nanoparticles Synthesis (Optional)	Introduction to bimetallic nanoparticles, selection of metals.	Lab Manual
Week 12	Bimetallic Nanoparticles Synthesis (Optional)	Procedure, characterization techniques, recording observations.	Lab Manual, Instruments
Week 13	Bimetallic Nanoparticles	Exploration of properties like magnetism, adsorption.	Lab Manual, Instruments

	Properties (Optional)		
Week 14	Recap, Review, and Assessment	Consolidation of knowledge, final assessment preparation.	

Facilitating the Achievement of Course Learning Outcomes

Practical No.	Course Learning Outcomes	Teaching Learning Activities	Assessment Task Methods
1	Understand Nanomaterial Synthesis	Demonstration and explanation of ZnO nanoparticles synthesis.	Observation and participation during synthesis
2	Understand Nanoparticle Preparation and Characterization	Introduction to silver nanoparticles preparation and characterization.	Participation in preparation and observation
3	Apply Diverse Nanoparticle Synthesis Approaches	Discussion on various routes for preparing diverse nanoparticles.	Selection of a synthesis route for practical
4	Verify Beer-Lambert Law with Nanoparticles	Introduction to Beer-Lambert law, preparation of nanoparticle samples.	Preparation of nanoparticle samples for analysis
5	Explore Bimetallic Nanoparticles	Introduction to bimetallic nanoparticles, guidance on synthesis.	Selection of metals and synthesis approach

SCCH310	**Green Processes of Chemistry**	L	T	P	C
Version 2.0		3	1	0	4
Total contact hours	60				
Pre-requisites/Exposure	12^{th} level Chemistry				
Co-requisites	--				

Course Objectives

On completion of this course, the students will be able to understand

1. Green chemistry and itsprinciples and processes in laboratoryreactions.
2. Green synthesis and reactions.

3. Green chemistry for sustainablesolutions.
4. Principles of green chemistry.
5. Design of chemical reactions/chemical synthesis using green chemistry principles.

Course Outcomes

By the end of this course, students will be able to:

CO1: Understand the twelve principles of green chemistry and will build the basic understanding of toxicity, hazard and risk associated with chemicalsubstances.

CO2: Understand stoichiometric calculations and relate them to green chemistry metrics. They will learn about atom economy and how it is different from percentageyield.

CO3: Learn to design safer chemical, products and processes that are less toxic than current alternatives. Hence, they will understand the meaning of inherently safer design for accident prevention and the principle "what you don't have can't harmyou"

CO4: Understand benefits of use of catalyst and bio catalyst, use of renewable feed stock which helps in energy efficiency and protection of environment, renewable energy sources, and importance of reactions in various greensolvents.

CO5: Appreciate the use of green chemistry reactions in problem solving skills, critical thinking and valuable skills to innovate and find out solution to environmental problems. Thus the students are able to realise that chemistry can be used to solve rather than cause environmentalproblems.

CO6: Analyze the green methods to increase productivity and ensure sustainability with absolute zero waste.

Catalog Description

Climate change and degradation of environment is a common global issue and sustainable development goals emphasize on reduction in pollution so as ensure better health, better sanitation and clean environment for all. Chemicals released from different industries as well as from chemical/ pharmaceutical labs add on to contaminants concentration in the environment. It is imperative to teach students the philosophy of green chemistry and how it can be helpful to reduce environmental pollution. Success stories and real world cases also motivate them to practice green chemistry. These days customers are demanding to know about a product: Is it green? Does it contribute to global warming? Was it made from non-renewable resources?
Students have many career opportunities as " green" is the path to success.

Course Content

UNIT	**I5 Lectures**

Introduction to Green Chemistry

Definition and principles of green chemistry.Historical context and evolution of green chemistry.Goals of Green Chemistry.Limitations/Obstacles in the pursuit of the goals of Green Chemistry.

UNIT II **15Lectures**

Principles of Green Chemistry and Designing a Chemical synthesis 12 Lectures

The 12 principles of green chemistry and their explanations and examples and special emphasis on Designing a Green Synthesis using these principles (Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions). Green metrics and assessment toolsLife cycle assessment (LCA)

UNIT III

Green Synthesis / Reactions **15 Lectures**

Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).

1. Microwave assisted reactions in water: (Hofmann Elimination, methylbenzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylation reaction).
2. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)
3. Surfactants for carbon dioxide - replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments.

4. Designing of Environmentally safe marine antifoulant.

5. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

6. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils

UNIT IV

Future Trends in Green Chemistry **15 Lectures**

Importance of catalysts in green chemistry, Homogeneous and heterogeneous catalysis

Enzyme catalysis and biocatalysis. Biomimetic, multifunctional reagents, Combinatorial green chemistry. Proliferation of solvent less reactions; co crystal controlled solid state synthesis (C2S3);

Green chemistry in sustainable development. Environmental impact assessments, Case studies showcasing green chemistry applications

Recommended Books/References:

1. Ahluwalia,V.K.,Kidwai,M.R.*NewTrendsinGreenChemistry*,AnamalayaPublishers(2005).

2. Anastas,P.T.&Warner,J.K,*GreenChemistry-TheoryandPractical*,OxfordUniversityPress (1998).

3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker(2001).

4. Cann, M.C.and Connely, M.E. *Real-World cases in Green Chemistry*, ACS(2000).

5. Ryan, M.A. and Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, (2002).

6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition,2010.

Open Educational Resources (OER)

Education in green chemistry and in sustainable chemistry: perspectives towards sustainability - Green Chemistry (RSC Publishing) DOI:10.1039/D0GC03313H

Green chemistry | Introduction | Twelve Principles of Green chemistry | Goals of Green Chemistry - Bing video

GREEN CHEMISTRTY |SYNTHESIS OF ADIPIC ACID |CONVENTIONAL AND GREEN ROUTE OF SYNTHESIS OF ADIPIC ACID - Bing video

Assessment & Evaluation

Components	**Quiz/Assignment/ Presentation**	**Mid Term Examination**	**Attendance**	**End Term Examination**
Weightage (%)	**20**	**20**	**10**	**50**

Course Code and Title	**Course Outcome**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
SCCH310	**CO1**	**3**	**3**	**3**	**3**	**3**	**3**	**2**		**3**		**3**	**3**	**3**	**3**

GREEN PROCESSES OF CHEMISTRY	**CO2**	**3**	**3**	**3**	**3**	**3**	**3**	**2**		**3**		**3**	**3**	**3**	**3**
	CO3	**3**	**3**	**3**	**3**	**3**	**3**	**2**		**3**		**3**	**3**	**3**	**3**
	CO4	**3**	**3**	**3**	**3**	**3**	**3**	**2**		**3**		**3**	**3**	**3**	**3**
	CO5	**3**	**3**	**3**	**3**	**3**	**3**	**2**		**3**		**3**	**3**	**3**	**3**
	CO6	**3**	**3**	**3**	**3**	**3**	**3**	**2**		**3**		**3**	**3**	**3**	**3**

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	Introduction to Green Chemistry
Local	-
Regional	-
National	-
Global	-
Employability	-
Entrepreneurship	Student centric methods, such as experiential learning, participative learning and problem-solving methodologies (2.3.1)
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit II	Principles of Green Chemistry and Designing a Chemical synthesis
Local	-
Regional	-
National	-
Global	-
Employability	-
Entrepreneurship	Student centric methods, such as experiential learning, participative learningand problem-solving methodologies (2.3.1)
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,

Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit III	
Local	-
Regional	-
National	-
Global	Chemical composition of atmosphere
Employability	-
Entrepreneurship	-
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit IV	
Local	-
Regional	-
National	-
Global	water quality parameters (DO, BOD, COD
Employability	-
Entrepreneurship	-
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
SDG	Skill for Decent Work; Sustainable Development and Global Citizenship
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India’s ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Global Education Knowledge, imagination/creativity, assumption of responsibility and for making decisions, planning, coordinating and organising ability

Teaching Plan:

Weekly Teaching Plan	**Topic/Unit No.**	**Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]**	**Teaching-Learning Method**
Week 1	Introduction to Green Chemistry	**TB1-2**	Lecture, Discussion
Week 2	Introduction to Green Chemistry	**TB1-2,3**	Lecture, Discussion
Week 3	PrinciplesofGreenChemistryandDesigningaChemicalsynthesis	Green chemistry | Introduction | Twelve Principles of Green chemistry | Goals of Green Chemistry - Bing video	Lecture, Discussion
Week 4	PrinciplesofGreenChemistryandDesigningaChemicalsynthesis	Green chemistry | Introduction | Twelve Principles of Green chemistry | Goals of Green Chemistry - Bing video	Lecture, Discussion
Week 5	PrinciplesofGreenChemistryandDesigningaChemicalsynthesis	Green chemistry | Introduction | Twelve Principles of Green chemistry | Goals of Green Chemistry - Bing video	Lecture, Discussion
Week 6	Green Synthesis / Reactions	**TB1**	Lecture
Week 7	Green Synthesis / Reactions	**TB1**	Lecture
Week 8	Green Synthesis / Reactions	**TB1**	Lecture

Week 9	Green Synthesis / Reactions	**TB1**	Lecture
Week 10	Green Synthesis / Reactions	**TB1**	Lecture
Week 11	Green Synthesis / Reactions	**TB1**	Lecture
Week 12	Green Synthesis / Reactions	**TB1**	Lecture
Week 13	Future Trends in Green Chemistry	**TB1**	Lecture, Discussion
Week 14	Future Trends in Green Chemistry	**TB1**	Lecture
Week 15	Future Trends in Green Chemistry	**TB1**	Lecture
Week 16	Future Trends in Green Chemistry	**TB1**	Lecture, Problem solving

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Understand the fundamental principles and objectives of green chemistry. Recognize the significance of sustainability and environmental considerations in chemical processes. Explain the challenges posed by conventional chemical practices and the need for greener	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.

	alternatives. Demonstrate awareness of the ethical, economic, and social dimensions of green chemistry.	homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	
2	Familiarize yourself with the twelve principles of green chemistry and their implications. Apply the principles of waste reduction, atom economy, and energy efficiency in chemical processes. Evaluate the environmental impact of different chemical pathways and propose greener alternatives. Identify opportunities to minimize hazards, toxicity, and resource depletion through sustainable practices.		
3	Comprehend the concept of green synthesis and its role in sustainable chemical manufacturing. Analyze various methods and techniques for reducing environmental impact in synthesis. Apply green chemistry principles to design synthetic routes with minimized waste generation. Compare and contrast the benefits and challenges of utilizing renewable feedstocks and eco-friendly solvents.		
4	Anticipate the evolving landscape of green synthesis and its potential contributions to sustainability. Predict emerging trends and technologies in green chemistry research and applications.		

	Evaluate the role of green synthesis in addressing global challenges such as climate change and resource scarcity. Formulate informed perspectives on the integration of green synthesis into industries and academia for a more sustainable future.		

SCCH362	**Green Processes of Chemistry Practicals**	L	T	P	C
Version 2.0		0	0	4	2
Contact Hours	30				
Pre-requisites/Exposure	12^{th} level Chemistry				
Co-requisites	--				

Course Objectives

On completion of this course, the students will be able to understand

1. Green chemistry and itsprinciples and processes in laboratoryreactions.
2. Green solvent/ solvent less reactions.
3. Design of chemical reactions/chemical synthesis using green chemistry principles.
4. Concept of atom economy, catalysts.

Course Outcomes

By the end of this course, students will be able to:

CO1: Understand the twelve principles of green chemistry
CO2: Understand stoichiometric calculations, atom economy and relate them to green chemistry metrics.
CO3: Learn to design safer chemical, products and processes by using green solvents, catalyst, energy efficient processes etc.
CO4: Understand benefits of use of catalyst and bio catalyst, which not only helps in increase in yield but also protects the environment by less usage of reactants.
Catalog Description

It is very important to learn new processes and synthetic tools to prepare novel compounds by doing either solvent less reactions or green solvents or performing reactions in microwaves or sonicators so as to promote sustainability. The techniques learnt in laboratories will help students to create/innovate/synthesize new processes and products.

Course Content

(Following is the list of suggestive experiments. However, depending upon available resources, experiments may be added/changes may be incorporated): (six experiments may be conducted)

1. Preparation and characterization of nanoparticles of gold using tealeaves.
2. Preparation of biodiesel from vegetable/ waste cookingoil.
3. Use of molecular model kit to stimulate the reaction to investigate how the atom economy illustrates GreenChemistry.
4. Reactionslikeaddition,elimination,substitutionandrearrangementmayalsobestudiedforthe calculation of atomeconomy.
5. Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead ofcyanide).
6. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dryice.
7. Mechanochemical solvent free synthesis ofazomethines
8. Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu(II)complex.
9. Photoreduction of benzophenone to benzopinacol in presence ofsunlight.

Recommended Books/References:

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice*, Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC(2002).
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC(2002).
4. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph, International Publishing ISBN 978-93-81141-55-7(2013).
5. Cann, M.C. and Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society(2008).
6. Cann,M.C.andThomas,P.*RealworldcasesinGreenChemistry*,AmericanChemicalSociety (2008).
7. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition,2010.
8. Pavia, D. L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach*, W.B.Saunders,1995.

(Note: A candidate has to perform at least eight experiments in the lab. Anysuitableexperiment may beadded.)

Assessment & Evaluation

Components	**Conduct of Experiment**	**Lab Record/Quizzes / Viva-Voce**	**Attendance**	**End Term PracticalExamination**
Weightage (%)	**20**	**20**	**10**	**50**

Course Code and Title	**Course Outcome**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
SCCH362G reen Processes of Chemistry Practicals	**CO1**	**3**	**3**	**3**	**3**	**3**		**3**	**3**			**3**	**3**	**3**	**3**
	CO2	**3**	**3**	**3**	**3**	**3**		**3**	**3**			**3**	**3**	**3**	**3**
	CO3	**3**	**3**	**3**	**3**	**3**		**3**	**3**			**3**	**3**	**3**	**3**
	CO4	**3**	**3**	**3**	**3**	**3**		**3**	**3**			**3**	**3**	**3**	**3**

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit	Learn new processes and synthetic tools to prepare novel compounds by doing either solvent less reactions or green solvents or performing reactions in microwaves or sonicators so as to promote sustainability.
Local	-
Regional	-
National	-
Global	Learn new processes and synthetic tools to prepare novel compounds by doing either solvent less reactions or green solvents
Employability	Student centric methods, such as experiential learning, participative learningand problem-solving methodologies (2.3.1)
Entrepreneurship	Entrepreneurship; Team work/ Creativity by designing research problem

Skill Development	Disciplinary knowledge; Research related skills; scientific skills,
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Sustainable Development and Global Citizenship Ensure access to affordable, reliable, sustainable and modern energy for all
SDG	Sustainable Development and Global Citizenship (SDG 4.7)Ensure access to affordable, reliable, sustainable and modern energy for all (SDG 7)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13)
POE/4th IR	Employability ; Hands-on Experience ; Skill Development

Teaching Plan:

Weekly Teaching Plan	**Topic/Unit No.**	**Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]**	**Teaching-Learning Method**
Week 1	Preparation and Characterization of Gold Nanoparticles	**TB2**	Experiment
Week 2	Preparation of Biodiesel from Cooking Oil	**TB2**	Experiment
Week 3	Calculating Atom Economy for Various Reactions	**TB2**	Experiment
Week 4	Calculating Atom Economy for Various Reactions	**TB2**	Experiment
Week 5	Benzoin Condensation with Thiamine Hydrochloride	**TB2**	Experiment
Week 6	Any green synthesis	**TB2**	Experiment
Week 7	Salicylic acid by green approach (using ceric ammoniumnitrate).	**TB2**	Experiment
Week 8	Mechanochemical Synthesis	**TB2**	Experim

	of Azomethines		ent
Week 9	Photoreduction of Benzophenone to Benzopinacol	**TB2**	Experiment
Week 10	Any green synthesis	**TB2**	Experiment
Week 11	Any green synthesis	**TB2**	Experiment
Week 12	Any green synthesis	**TB2**	Experiment
Week 13	Revision and Review of Experiments		Experiment

Facilitating the Achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching Learning Activity**	**Assessment Task Methods**
1	Throughout the experiment classes, students will engage in a series of hands-on activities aligned with the course objectives. Starting with the synthesis and characterization of gold nanoparticles from tealeaves, they'll progress to producing biodiesel from cooking oil. They'll then explore atom economy concepts through molecular model kit simulations and analyze atom economy in various reactions. Following this, students will undertake eco-friendly benzoin condensation using Thiamine Hydrochloride, extract D-limonene using CO2, and master mechanochemical azomethine synthesis. Microwave-assisted, solvent-free Cu(II) phthalocyanine complex synthesis and photoreduction of benzophenone to	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	Experiment

SCCH403	Advanced Material Chemistry	L	T	P	C
Version 3.0		3	1	0	4
Total Contact Hours	60				
Pre-requisites/Exposure	Physical chemistry or an equivalent course is recommended				
Co-requisites	--				

	benzopinacol will showcase advanced techniques. The final weeks will focus on review, revision, assessments, and in-depth discussions, fostering a well-rounded understanding of green chemistry principles and sustainable synthesis methods.		

DISCIPLINE SPECIFIC ELECTIVE –II

COURSE OBJECTIVES

- To understand the crystal structure of solids, fundamental of lattices, unit cell, atomic coordinates, Bravais lattices, crystal direction and planes, types of close packing, packing efficiency, radius ratios; few important crystal structures.
- To acquire the knowledge of synthesis of Inorganic solids in solid state, solution phase and vapor phase by the processes as precipitation, hydrothermal, sol-gel, surfactant based synthesis.
- Able to synthesize nanowires and nanotubes by CVD and MOCVD method along with understanding of Magnetic properties of nanoparticles.
- To develop biodegradable polymers, conducting polymers, fibers and rubber.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Able to interpret the basic materials chemistry that underpins current and emerging technologies as well as some of the novel classes of materials being developed for future applications.

CO2: To acquire knowledge of instrumental characterization methods and their interpretation.

CO3: Gain knowledge on wide variety of advanced materials like nano and smart materials which have excellent physical and chemical properties.

CO4: Identify different types of polymers, composites and their applications in various fields.

CO5: Get trained in conducting scientific experiments, recording and analyzing experimental data.

CO6: Learn about the preparation of inorganic compounds.

CO7: Solve problems and carry out scientific investigations.

CATALOG DESCRIPTION

Materials chemistry is the study of the synthesis, structure, properties, and application of solid materials. Our technology-driven world is fueled by advances in materials chemistry with examples of application in areas such as microelectronics, polymers, and energy technology. This course will explain the application of materials chemistry through the materials properties and characterization, detailing how the crystalline and molecular structure of materials can be related to electronic, optical, thermal, and mechanical properties.

COURSE CONTENT

Unit I: **15Lecture**

Crystal structure of solids

Fundamental of lattices, unit cell, atomic coordinates, Bravais lattices, crystal direction and planes, types of close packing, packing efficiency, radius ratios; few important crystal structures.
Synthesis of Inorganic solids; solid state, solution phase and vapor phase synthesis; precipitation, hydrothermal, sol-gel, surfactant-based synthesis.Growth of single crystals.
Crystal structure determination by X-ray diffraction, d-spacing formula, symmetrically absent reflections, Multiplicities, Scattering of X-rays by crystal.Single crystal and powder diffraction.Electron and neutron diffraction.Concept of reciprocal lattice.Electron microscopy techniques.

Unit II: **15Lecture**

Nanomaterial fundamentals

Synthesis: Bottom-up vs. Top-down Methods. Solution phase synthetic methods. Role of surfactant in shape and size control of nanomaterials.Synthesis of nanowires and nanotubes by CVD and MOCVD method.

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Unit III: **15Lecture**

Nanomaterials Characterization: XRD of nanomaterials, Electron microscopy (SEM, TEM, HRTEM and EDX) of nanomaterials, Scanning probe microscopy.

Nanomaterial properties and applications: Magnetic properties of nanoparticles; superparamagnetism, ferromagnetism in antiferromagnetic nanoparticles and single domain to multidomain transition. magnetic nanoparticles as MRI contrast agents.

Unit IV: **15Lecture**

Frontier areas of polymer science and technology

Conducting polymers: basic principles of conducting polymers, delocalized electronic states of conjugated polymers, polyanilines, polyacetylenes, polythiophene, applications of conducting polymers.

Biodegradable polymers: Definition classification of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers, polyhydroxy alkanoates, polycarpolactone, poly(vinyl alcohol), polyacetic acid, application of biodegradable and biomedical polymers, contact lens, dental polymers, artificial heart, kidney, skin, and blood cells.

Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA.

Rubber: Compounding and elastomeric properties, vulcanization, reinforcement.

Reference Books:

1. Zhen Guo and Li Tan, Fundamentals and Applications of Nanomaterials. 2009, Artech House, London Publication.
2. Physical methods for chemistry: R. S. Drago, 1992, Saunders college publication.
3. Polymerscience,V.R.Gowariker,N.V.Viswanathan,J.Sreedhar,NewAgeInternational(P) Ltd.,2015.
4. P. J. Flory, Principle of polymer chemistry, Cornell University Press.
5. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.
6. V. Gowriker, N. V. Viswanathan, J. Sreedhar, Polymer Science, New Age Int.Publication, 2019.

Open Educational Resources (OER)

1. https://www.chemistrynotesinfo.com/2019/08/Solid-State-Chemistry-BSc-Chemistry-Notes.html
2. https://www.intechopen.com/chapters/72926
3. efaidnbmnnnibpcajpcglclefindmkaj/https://old.amu.ac.in/emp/studym/100005514.pdf
4. efaidnbmnnnibpcajpcglclefindmkaj/https://ccsuniversity.ac.in/bridge-library/pdf/L-3%20Synthesis%20of%20Nanostructured%20Materials%20Prof%20BPS.pdf
5. https://link.springer.com/book/10.1007/978-1-62703-776-1
6. https://link.springer.com/book/10.1007/978-981-16-8755-6

Assessment & Evaluation

Components	**Attendance**	**Quiz/Assignment/ Presentation**	**Mid Term Examination**	**End Term Examination**
Weightage (%)	**10**	**20**	**20**	**50**

Programme and Course Mapping

Course Code and Title	**Course Outcome**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
SCCH403 Advanced Material Chemistry	**CO1**	**3**													
	CO2				**3**								**3**		
	CO3	**3**												**3**	
	CO4	**3**													
	CO5				**3**									**3**	
	CO6						**3**								**3**

Unit I	Crystal structure of solids

Local	Local materials science and manufacturing industries can apply crystallography principles.
Regional	-
National	Contribution to national-level understanding of crystallography, materials science, and applications.
Global	Engaging in global discussions on crystallography and materials science.
Employability	-
Entrepreneurship	Identifying opportunities in materials manufacturing and research.
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	Nanomaterial fundamentals
Local	-
Regional	-
National	Contribution to national understanding of nanomaterials and their applications.
Global	Engaging in global discussions on nanomaterials and nanotechnology.
Employability	-
Entrepreneurship	Identifying opportunities in nanomaterials-based technologies and applications.
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Considering the environmental impact of nanomaterials.
Unit III	Nanomaterial’s Characterization
Local	Local research and industries may apply nanomaterials characterization techniques.
Regional	-
National	-
Global	Engaging in global discussions on nanomaterials characterization techniques.
Employability	Building knowledge and skills for careers in nanomaterials characterization and applications.
Entrepreneurship	Identifying opportunities in nanomaterials characterization services and applications.
Skill Development	-
Professional Ethics	-
Gender	-

Human Values	-
Environment & Sustainability	-
Unit IV	Frontier areas of polymer science and technology
Local	-
Regional	Regional polymer manufacturing and research sectors can benefit from polymer science knowledge.
National	Contribution to the national understanding of polymer science, materials, and applications.
Global	Engaging in global discussions on polymer science and its technological applications.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Considering the environmental impact of polymers and their disposal.
SDG	Acquire theknowledge and skills needed to promote sustainable development
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India’s ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Technical Skills that match Industry Needs/ Exposure on advance materials and techniques

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Method
Week 1	**Unit 1:** Fundamental of lattices, unit cell, atomic coordinates, Bravais lattices, crystal direction and planes, types of close packing, packing	**RB-1/ OER-1**	Group Discussion/Presentation

Week 2	**Unit 1:** Synthesis of Inorganic solids; solid state, solution phase and vapor phase synthesis; precipitation, hydrothermal, sol-gel,	**RB-1/ OER-2**	Group Discussion/Presentation
Week 3	**Unit 1:** Growth of single crystals. Crystal structure determination by X-ray diffraction, d-spacing formula, symmetrically	**RB-1/ OER-2**	Group Discussion/Presentation
Week 4	**Unit 1:** Scattering of X-rays by an atom and a crystal. Single crystal and powder diffraction. Electron and neutron diffraction. Concept of reciprocal lattice. Electron microscopy techniques.	**RB-1/ OER-2**	Group Discussion/Presentation
Week 5	**Unit 2:**Synthesis: Bottom-up vs. Top-down Methods. Solution phase synthetic methods.	**RB-1/2/OER-3**	Group Discussion/Presentation
Week 6	**Unit 2:** Role of surfactant in shape and size control of nanomaterials. Synthesis of nanowires and nanotubes by CVD and MOCVD method.	**RB-1/2/OER-3**	Group Discussion/Presentation
Week 7	**Unit 3:** Nanomaterials Characterization: XRD of nanomaterials, Electron microscopy (SEM, TEM, HRTEM and EDX) of nanomaterials compounds, poly- halide ions, pseudo-	**RB-1/OER-4**	Group Discussion/Presentation
Week 8	**Unit 3:** Scanning probe microscopy. Nanomaterial properties and applications: Magnetic properties of nanoparticles;	**RB-1/2/OER-3**	Group Discussion/Presentation

Week 9	**Unit 3:** super paramagnetism, ferromagnetism in antiferromagnetic nanoparticles and single domain to multidomain transition.	**RB-1/2/OER-3**	Group Discussion/Presentation
Week 10	**Unit 4:** Magnetic nanoparticles as MRI contrast agents. Frontier areas of polymer science and technology Conducting polymers: basic	**RB-4/5/OER-4/5**	Group Discussion/Presentation
Week 11	**Unit 4:** Biodegradable polymers: Definition classification of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten	**RB-4/5/OER-4/5**	Group Discussion/Presentation
Week 12	**Unit 4:**polyhydroxy alkanoates, polycarpolactone, poly(vinyl alcohol), polyacetic acid, application of biodegradable and biomedical polymers, contact lens, dental	**RB-4/5/OER-4/5**	Group Discussion/Presentation
Week 13	Revision		Group Discussion/Presentation
Week 14	**Revision**		Group Discussion/Presentation

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning	Teaching Learning	Assessment

No.	Outcomes	Activity	Task Methods
1	Understand the fundamental concepts of advanced material chemistry, including crystal structures, defects, and phase transformations, and their impact on material properties.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Describe the synthesis methods for advanced materials, such as nanomaterials, polymers, ceramics, and composites, and explain the influence of synthesis parameters on material characteristics.		
3	Demonstrate proficiency in various techniques used to characterize advanced materials, such as X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and spectroscopic methods.		
4	Understand the principles of nanotechnology and its applications in advanced materials, such as nanocomposites,		

	nanoelectronics, and nanomedicine.		

SCCH455	**ADVANCE MATERIAL CHEMISTRY PRACTICALS**	**L**	**T**	**P**	**C**
Version 3.0		**0**	**0**	**4**	**2**
Total Contact Hours	**30**				
Pre-requisites/Exposure	**Basics of Analytical Chemistry**				
Co-requisites	**--**				

Course Objectives

1. To develop an understanding of the range and uses of analytical methods in chemistry.
2. To establish an appreciation of the role of chemistry in quantitative and qualitative analysis

3. To develop an understanding of the broad role of the chemist in measurement and problem solving for analytical tasks.

4. To provide experience in some scientific methods employed in analytical chemistry.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Experience of research design and management.

CO2: Handle advanced instrumentation or techniques.

CO3: Able to produce of scientific reports.

CO4: Assess the appropriate methods of data collection/analysis to address the research question.

CO5: Understand the basic principles associated with spectrophotometry and discuss how these are applied to the various specific applications.

CO6: Discuss the practical considerations appropriate for the application of these methods to typical chemical analyses (e.g. sensitivity, detection limits, linear response ranges, interferences, etc.)

CATALOG DESCRIPTION

This course first offers an introduction to nanomaterials and their preparation method by bottom-up and top-down method. Sampling, Specific analytical techniques or concepts covered are: complexometric titration, spectrophotometric analysis and morphology analysis of particles. These topics will be covered from the point of view of theory, the associated analytical instrumentation, and relevant computational methods.

COURSE CONTENT

List of Laboratory experiments

(The lists of experiments are suggestive. However, faculties/academic bodies may add more experiments/references or incorporate suitable revisions based on infrastructure facilities available).

1. Preparation of gold and silver nano-particles.
2. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein

3. Determination of composition of dolomite (by complexometric titration).
4. Analysis of XRD pattern of few selected crystals like $NaNO_3$, $CaCl_2$, etc.; Indexing of a given powder diffraction pattern of a cubic crystalline system.
5. Interpretation of FTIR, NMR and UV-Vis data of given material.
6. Estimation of particle size from the BET, SEM, TEM techniques.

Recommended books/Reference Book:

1.Fahlman, B.D. *Materials Chemistry*, Springer, 2004.

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Open Educational Resources (OER)

- (12) Gold Nanoparticles Synthesis - YouTube
- (12) Making of Silver Nanoparticles - YouTube
- (12) Interfacial polymerization of polyamide - YouTube
- (12) UNIT-II(PART-6)(PAPER-III)ANALYSIS OF LIMESTONE, DOLOMITE & MAGNESITE (PART-A) - YouTube
- (12) Determination of Crystal Structures by XRD Patterns - YouTube
- lehigh.edu/~kjs0/carey-13.PDF
- iitk.ac.in/che/pdf/resources/BET-TPX-Chemi-reading-material.pdf

Assessment & Evaluation

Components	Conduct of Experiment	Lab Record/Quizzes/ Viva-Voce	Attendance	End Term Practical Examination
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course Code and Title	Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PSO 1	PSO 2	PSO 3	PSO 4
SCCH455 Advanced Material Chemistry Practical	**CO1**	**3**				**3**						**2**			
	CO2		**2**			**3**									
	CO3		**3**											**3**	**3**
	CO4	**3**			**3**	**3**									
	CO5	**3**			**3**	**3**									**3**
	CO6	**2**				**2**								**3**	

Unit	1. Preparation of gold and silver Nano-particles. 2. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein 3. Determination of composition of dolomite (by complex metric titration). 4 Analysis of XRD pattern of few selected crystals like $NaNO_3$, $CaCl_2$, etc.; Indexing of a given powder diffraction pattern of a cubic crystalline system. 5. Interpretation of FTIR, NMR and UV-Vis data of given material. 6. Estimation of particle size from the BET, SEM techniques.
Local	-
Regional	-
National	-
Global	1.Preparation of gold and silver Nano-particles. 2. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein 3. Determination of composition of dolomite (by complex metric titration). 4 Analysis of XRD pattern of few selected crystals like $NaNO_3$, $CaCl_2$, etc.; Indexing of a given powder diffraction pattern of a cubic crystalline system. 5. Interpretation of FTIR, NMR and UV-Vis data of given material. 6. Estimation of particle size from the BET, SEM techniques.
Employability	Knowledge and skills in the identification and analysis of organic compounds containing hetero atoms are highly valued in industries such as pharmaceuticals, chemical research, quality control, and forensic science, enhancing employability prospects.
Entrepreneurship	-
Skill	hands on experience on synthesis and characterization techniques

Development	
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	The knowledge gained from the analysis of organic compounds can contribute to environmental studies, particularly in analyzing organic pollutants or monitoring chemical processes that impact the environment.
SDG	Skills for Decent Work (SDG 4.4), Sustainable Development and Global Citizenship (SDG 4.7), Ensure availability and sustainable management of water and sanitation for all (SDG 6); Promote peaceful and inclusive societies for sustainable development,
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13), Promoting High Quality Research (18.1-18.9); Technology use and integration
POE/4th IR	Technical Skills that match Industry Needs;Focus on Employability Skills (Local/Regional and Global)Team Work, Technology Use and Integration (23.1-23.13), Internship Program; Consulting Field Projects/ hands on experience, projects (In industry/ Research Lab)

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference	Teaching-Learning Method
Week 1	Preparation of gold nanoparticles	**RB-I/OER-I**	**Discussion and Experiment**
Week 2	Preparation of Silver nanoparticles	**RB-I/OER-2**	**Discussion and Experiment**
Week 3	Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and	**RB-I/OER-III**	**Discussion and Experiment**
Week 4	Determination of composition of dolomite (by complexometric titration).	**RB-I/OER-IV**	**Discussion and Experiment**
Week 5	Analysis of XRD pattern of few selected crystals like $NaNO_3$, $CaCl_2$, etc.; Indexing of a given	**RB-I/OER-V**	**Discussion and Experiment**
Week 6	Interpretation of FT-IR data of given material.	**RB-I/OER-VI**	**Discussion and Experiment**
Week 7	Interpretation of UV-Vis data of given material.	**RB-I/OER-VI**	**Discussion and Experiment**

Week 8	Interpretation of NMR data of given material	**RB-I/OER-VI**	**Discussion and Experiment**
Week 9	Estimation of particle size from the BET techniques.	**RB-I/OER-VII**	**Discussion and Experiment**
Week 10	Estimation of particle size from the SEM techniques.	**RB-I/OER-VII**	**Discussion and Experiment**
Week 11	Revision		**Discussion and Experiment**
Week 12	Revision		**Discussion and Experiment**
Week 13	Revision		**Discussion and Experiment**
Week 14	Revision		**Discussion and Experiment**

Facilitating the Achievement of Course Learning Outcomes

For Example:

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Gain valuable hands-on experience in working with advanced materials and the associated equipment and techniques.	(i) Each experiment to be explained with illustrations. (ii) Students to be encouraged to prepare various inorganic compounds using different synthetic methods (iii) Introduce students to qualitative analysis techniques to identify the presence of specific ions in a given sample. (iv) Stu Conduct titration experiments involving inorganic compounds. Students can learn how to perform accurate measurements and calculate	• Experiment Performance and class discussions. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Develop critical skills required for scientific research, such as experimental design, data analysis, and effective communication of scientific findings.		

SCCH405	**ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY**	**L**	**T**	**P**	**C**
Version 3.0		**3**	**1**	**0**	**4**
Total Contact Hours	**60**				
Pre-requisites/Exposure	**Basics of transition elements and metal ions present biological system**				
Co-requisites	**--**				

		concentrations or quantities of unknown substances.	

COURSE OBJECTIVES

1. To understand variable oxidation state of some transition elements.
2. To learn about the basics of organometallic compounds.
3. To describe the role of metal ions in biological system
4. To learn synthesis of organometallic compounds like ferrocene.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Learn about variable oxidation state of transition elements like Cr, Fe, Co and Ni.

CO2: Learn develop the ability to understand basics of organometallic compounds, concepts of hepaticity, EAN rule and back pi bonding.

CO3: Get information about various common compounds of transitions elements which are used in laboratory on daily basis.

CO4: To predict and understand the function of Mg2+ and Ca2+ ions in daily basis life.

CO5: Familiar with synergic effect that have wide application in chemistry especially metathesis, catalysis and infra-red analysis.

CO6: Able to describe role and chemistry of metal ions in human life.

CATALOG DESCRIPTION

This course imparts basic knowledge of organometallic compounds including their structure, preparation and properties. This course introduces different types of mononuclear and polynuclear carbonyl of 3d metals. The course will provide a basic understanding of the metal ions in biological system like role of Ca^{2+} in blood clotting, Mg^{2+} in energy production.

COURSE CONTENT

Unit I: **8 lecture**

Chemistry of 3d metals:

Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds ofCr, K2Cr2O7, KMnO4, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$,Na3[Co(NO2)6].

Unit II: **16lecture**

Organometallic Compounds:

Definition and classification of organometallic compounds on the basis of bond type.Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series.Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls..

Unit III: **16 lecture**

Metal Alkyls:

Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds.Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity.Comparison of aromaticity and reactivity with that of benzene.
Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals.p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Unit IV: **8Lecture**

Bioinorganic chemistry:

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na+, K+ and Mg2+ ions: Na/K pump; Role of Mg2+ ions in energy production and chlorophyll. Role of Ca2+ in blood clotting, stabilization of protein structures and structural role (bones).

Recommended books/reference books

• Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
• Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH,1999
• Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
• Greenwood, N.N. & Earnshaw A. Chemistry of the Elements, Butterworth-Heinemann,1997

Open Educational Resources (OER)

https://www.arsdcollege.ac.in/wp-content/uploads/2020/03/chemistry-of-3d-metal-notes_compressed.pdf
TRANSITION ELEMENTS (B.SC-II) INORGANIC CHEMISTRY PAPER-I.pdf (hcpgcollege.edu.in)
Microsoft Word - Course Introduction BCHT 147 Vol 1 English _28.04.2022_ (egyankosh.ac.in)
SCYA5302.pdf (sathyabama.ac.in)
Bioinorganic Chemistry (1).pdf (shivajicollege.ac.in)

Assessment & Evaluation

Components	Attendance	Quiz/Assignment/ Presentation	Mid Term Examination	End Term Examination

Weightage (%)	10	20	20	50

Programme and Course Mapping

Course Code and Title	Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PS O1	PS O2	PS O3	PS O4
SCCH405 Organometallic and Bioinorganic Chemistry	**CO1**	3			2				1						
	CO2		3									3		1	
	CO3	3			2			1							
	CO4									3					3
	CO5	3											2		
	CO6									3					3

Unit I	Chemistry of 3d metals
Local	Local industries may use these compounds, promoting local materials development.
Regional	-
National	-
Global	Engaging in global discussions on coordination chemistry and complex compounds.
Employability	Building foundational knowledge for careers in chemistry and materials research.
Entrepreneurship	-
Skill Development	Developing expertise in inorganic chemistry and compound synthesis.
Professional Ethics	-
Gender	-
Human Values	-
Environment &	-

Sustainability	
Unit II	Organometallic Compounds
Local	-
Regional	Regional research institutions can benefit from knowledge of organometallic compounds.
National	-
Global	Engaging in global discussions on organometallic compounds and their applications.
Employability	Building knowledge and skills for careers in organometallic chemistry and catalysis.
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Metal Alkyls
Local	-
Regional	-
National	Contribution to national understanding of organometallic chemistry.
Global	-
Employability	Building knowledge and skills for careers in chemical synthesis and catalysis.
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Bioinorganic Chemistry
Local	-
Regional	-
National	-
Global	Bioinorganic Chemistry
Employability	Building knowledge and skills for careers in bioinorganic chemistry and healthcare.
Entrepreneurship	-

Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Considering the environmental impact of metal ions in biological systems.
SDG	Scholarships for Higher Education 4b,
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3) Prepare students for more meaningful and satisfyinglives (9.1.1)
POE/4th IR	Effective and sustainable learning required for employability

Teaching Plan:

Weekly Teaching Plan	**Topic/Unit No.**	**Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ Open Education Resources [OER]**	**Teaching-Learning Method**
Week 1	**Unit 1:** Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds ofCr, K_2Cr_2O7,	**RB-2/ OER-1**	Group Discussion/Presentation
Week 2	**Unit 1:** $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$,$Na_3[Co(NO_2)_6]$.	**RB-2/ OER-1**	Group Discussion/Presentation

Week 3	**Unit 2:** Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule,	**RB-2/ OER-2/3**	Group Discussion/Presentation
Week 4	**Unit 2:** Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.	**RB-2/ OER-2/3**	Group Discussion/Presentation
Week 5	**Unit 2:** pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.	**RB-2/ OER-2/3**	Group Discussion/Presentation
Week 6	**Unit 2:** Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.	**RB-2/ OER-2/3**	Group Discussion/Presentation
Week 7	**Unit 3:** Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst).	**RB-2/OER-4**	Group Discussion/Presentation
Week 8	**Unit 3:** Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation).	**RB-2/OER-4**	Group Discussion/Presentation
Week 9	**Unit 3:** Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.	**RB-2/OER-4**	Group Discussion/Pr

	Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds).		esentation
Week 10	**Unit 4:** Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.	**RB-2/OER-4**	Group Discussion/Presentation
Week 11	**Unit 4:** A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump;	**RB-2/OER-5**	Group Discussion/Presentation
Week 12	**Unit 4:**Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).	**RB-2/OER-5**	Group Discussion/Presentation
Week 13	**Revision**		Group Discussion/Presentation
Week 14	**Revision**		Group Discussion/Presentation

Facilitating the Achievement of Course Learning Outcomes

For Example:

Unit No.	**Course Learning Outcomes**	**Teaching Learning Activity**	**Assessment Task Methods**
1	Understand the basics of transition elements	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Describe the synthesis methods and reactions of organometallic compounds, including transition metal complexes and their applications in catalysis and organic synthesis.		
3	Explain the structure and reactivity of various organometallic species, such as metal carbonyls, metal alkyls, and metal hydrides.		
4	Understand the role of metal ions in biological systems, including metalloproteins, metalloenzymes, and metal cofactors in biological processes.		

COURSE OBJECTIVES

1. To learn about synthesis of coordination complexes.

SCCH457	**ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY PRACTICALS**	**L**	**T**	**P**	**C**
Version 3.0		**0**	**0**	**4**	**2**
Total Contact Hours	**30**				
Pre-requisites/Exposure	**Basics of water quality parameters**				
Co-requisites	--				

2. To learn about preparation of Grignard reagent and dye using Grignard reagent.

3. To determine conductivity of metal complexes.

4. Performing risk assessment of chemical experiments and chemical analytical activity

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Understand simple methods used for synthesis of metal complexes.

CO2: Describe the applications of Grignard reagent used for preparation of dye and other compounds.

CO3: Enable to prepare Schiff base-metal complexes and their application for water purification.

CO4: Students will learn the application of spectroscopy and conductometry in such ways to make informed conclusions and decisions about controversial environmental issues.

CO5: Learn to work with others as part of a team to solve scientific problems.

CO6: Trained in analytical and instrumental skills required for their development.

CATALOG DESCRIPTION

This course covers some simple methods for preparation of metal complexes in the laboratory and their identification using different analytic techniques like spectroscopy and conductometry. The course also gives hand on experience to use analytical instruments which will help them to think about the research work.

COURSE CONTENT

List of Laboratory experiments

(necessary infrastructure may be developed and adequate precaution should be maintained to conduct such experiments; instructor may demonstate the experiment to students)

1. Rection of metal with halide – preparation of Grignard reagent. (only demonstration purpose)

2. Grignard preparation of dye (malachite green (using methylbenoate)/crystal violet (using diethylcarbonate) (starting material as p-bromo N, N-dimethyl aniline) (only demonstration purpose)

3. Preparation of various Schiff base-metal complexes and their identification using spectroscopy.

4. Preparation of any two of the following complexes and measurement of their conductivity measurement:

a. tetraamminecarbonatocobalt (III) nitrate

b. tetraamminecopper (II)sulphate

c. potassium trioxalatoferrate (III) trihydrate

Recommended books/reference books

1. Synthesis of organometallic compounds: A practical guide, S. Komiya,Wiley.

2. A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7thEdn.

3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*,Prentice-Hall,

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Open Educational Resources (OER)

- (12) UTSC - Chemistry Lab Grignard Reaction Experiment - YouTube
- (12) Malachite Synthesis: General Chemistry Lab 6 - YouTube
- (12) Gram stain: Preparing Crystal Violet - YouTube

- (12) Synthesis and Characterization of Metal Complexes with Schiff Base Ligands (An UG Lab. Exp.) - YouTube
- (12) [Co(NH3)4CO3] Synthesis of - YouTube
- (12) TETRAAMMINECOPPER(II) SULFATE ([Cu(NH3)4]SO4.H2O) EXPERIMENT - YouTube
- (12) ChemLab - 5. Preparation and Analysis of Potassium Trioxalatoferrate (III) Trihydrate - YouTube

Assessment & Evaluation

Components	**Conduct of Experiment**	**Lab Record/Quizzes/ Viva-Voce**	**Attendance**	**End Term Practical Examination**
Weightage (%)	**20**	**20**	**10**	**50**

Programme and Course Mapping

Course Code and Title	**Course Outcome**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
SCCH457 Organometallic and Bioinorganic Chemistry Practicals	**CO1**	3										3			
	CO2					2									
	CO3						3						2		
	CO4						3							2	
	CO5								3						3
	CO6		2												3

Unit	Laboratory experiments
Local	-
Regional	-
National	-
Global	-
Employability	-
Entrepreneurship	-
Skill Development	Haqnds on learning experience on simple methods for preparation of metal complexes in the laboratory and their identification using different analytic techniques like spectroscopy and conductometry. The course also gives hand on experience to use analytical instruments which will help them to think about the research work.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Acquire relevant skills, includingtechnical and vocational skills, for employment, decent jobs and entrepreneurship (SDG 4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India’s ; India's Higher Education System (9.1- 9.3) develop good,thoughtful, well-rounded, and creative individuals (9.1.1);Towards a More Holistic and multidisciplinary Education (11.1- 11.13)
POE/4th IR	Technical Skills that match Industry Needs,Focus on Employability Skills (Local/Regional and Global)Team Work

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Method
Week 1	Reaction of metal with halide – preparation of Grignard reagent. (only demonstration purpose)	RB-2/ OER-1	Discussion and Experiment
Week 2	Grignard preparation of dye (malachite green (using methylbenoate) (using diethylcarbonate) (starting material as p-bromo N, N-dimethyl aniline)	RB-2/ OER-2	Discussion and Experiment
Week 3	Prepration of crystal violet (using diethylcarbonate)	RB-2/ OER-3	Discussion and Experiment
Week 4	Preparation of various Schiff base-metal complexes and their identification using spectroscopy.	RB-2/ OER-4	Discussion and Experiment
Week 5	Preparation of tetraamminecarbonatocob2. alt (III) nitrate	RB-2/ OER-5	Discussion and Experiment
Week 6	Preparation of tetra ammine copper (II) sulphate	RB-2/ OER-6	Discussion and Experiment

Week 7	Preparation of potassium trioxalato ferrate (III) trihydrate	RB-2/ OER-7	Discussion and Experiment
Week 8	Revision		Discussion and Experiment
Week 9	Revision		Discussion and Experiment
Week 10	Revision		Discussion and Experiment
Week 11	Revision		Discussion and Experiment
Week 12	Revision		Discussion and Experiment
Week 13	Revision		Discussion and Experiment
Week 14	Revision		Discussion and Experiment

Facilitating the Achievement of Course Learning Outcomes

For Example:

Unit No.	**Course Learning Outcomes**	**Teaching Learning Activity**	**Assessment Task Methods**
1	Understand the basics of transition elements	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term
2	Describe the synthesis		

	methods and reactions of organometallic compounds, including transition metal complexes and their applications in catalysis and organic synthesis.	given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	examinations. • Practical and viva-voce examinations. • End-term examinations.
3	Explain the structure and reactivity of various organometallic species, such as metal carbonyls, metal alkyls, and metal hydrides.		
4	Understand the role of metal ions in biological systems, including metalloproteins, metalloenzymes, and metal cofactors in biological processes.		

SCCH407	**Polymer Chemistry**	L	T	P	C
Version 3.0		3	1	0	4
Total Contact Hours	**60**				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

Course Objectives

1. To use essential descriptions about polymer chemistry, and define related concepts.
2. To evaluate the structure and molecular weight of polymers.
3. To learn and interpret stereochemistry of polymerization.
4. To learn about modern techniques that could be used to identify and characterize any give given polymer.

Course Outcomes

On completion of this course, the students will be able to

CO 1: understand the fundamental concepts of polymers and their classification.

CO 2: analyse the relationship between polymeric structure and properties.

CO 3: evaluate the various industrial polymerization methods and their significance.

CO 4: apply advanced techniques for the characterization and identification of polymers.

Catalog Description

The topics included in this course will help students to study the classification and properties related to the polymers. They will learn about polymeric structure and property relationship. They will also study about the different types of molecular weights and their distribution. It will enable them to understand stereochemistry of polymerisation reactions. The course discusses various experimental techniques to identify and characterize polymers. This course also includes detailed study of kinetics and mechanism of the polymerisation process and uses of polymers.

Course Content

Unit I: **15 Lectures**

Introduction: Polymer, monomer, examples of polymers, biopolymers, classification, polymerization process, degree of polymerization, condensation, addition polymers, kinetics of addition polymerization process.

Unit II: 15 Lectures

Polymeric Structure and Property Relationship: Structure of polymers - Linear, branched, cross linked, and network polymers, molecular weight (number average, weight average, viscosity average) and distribution of molecular weight, polydispersityindex,crystallinityinpolymer,meltingtemperatureandglasstransitiontemperature, Volumetric properties - molar volume, density, Van der Waals volume - Coefficient of linear thermal expansion and volumetric thermal expansion - Pressure volume temperature (PVT) relationship.

Unit III: 15 Lectures

Polymerization Chemistry: Industrial methods of polymerization such as a bulk, solution, emulsion, suspension. Stereochemistryofpolymersandstereo-specificpolymerization,Catalysts-theirutilityinpolymers and stereo-specific polymerizations, Catalysts their utility in polymer manufacture, Zieglar-Natta, Metallocene and others.

Unit IV: 15 Lectures

CharacterizationofPolymers: MolecularWeightDeterminationbyLightScattering,Osmometry,End-GroupAnalysis,Viscosity, Gel Permeation Chromatography; Application, of FTIR, UV-visible, NMR, and Mass Spectroscopy for Identification ofpolymers.

Text Books

1. D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition ElsevierScientific, Publishing Company Amsterdam - Oxford - Newyork.1990.

2. J.E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt,1996.

3. Reaction Engineering of Step Growth Polymerization, S K Gupta and Anil Kumar, Plenum Press, 1987

Reference Books/Materials

1. Odian; George, Principles of Polymerization, McGraw-Hill Book Co., New York(1970).

2. W. Billmeyer, Text book of polymer science, 3rdEdn., 2007,Wiley.

3. J.R.Fried, Polymer Science and Technology, (2005), PHIpublication.

4. Billmeyer Jr.; Fred W., Textbook of Polymer Science, Wiley- Interscience Publishers, New York (1962).

Open Educational Resources (OER)

- https://ocw.mit.edu/courses/materials-science-and-engineering/3-042j-introduction-to-polymers-fall-2006/
- http://www.pslc.ws/macrog/maindir.htm
- http://polymerdatabase.com/
- https://www.khanacademy.org/science/organic-chemistry/bond-line-structures-alkanes-cycloalkanes/polymers-organic/v/polymers-introduction
- http://chemcollective.org/activities/simulations/polymerization
- http://nroer.gov.in/home/
- http://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/polymers.htm
- https://onlinelibrary.wiley.com/journal/10991564
- https://www.youtube.com/watch?v=jABU_vd0lIc

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Attendance	Quiz/Assignment/ Presentation	Mid Term Examination	End Term Examination
Weightage (%)	10	20	20	50

Programme and Course Mapping

Course Code and Title	Course Outcomes (COs)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO1	PSO2	PSO3	PSO4
SCCH407 Polymer	CO1	3	2	1	2	2	3	2	2	2	2	3	2	3	3
	CO2	1	2	2	1	1	1	1	2	1	1	2	2	2	2
	CO3	2	2	2	2	1	2	1	1	2	2	2	2	1	2

Chemistry	**CO4**	2	3	1	3	1	1	2	2	1	2	1	1	2	2

1 = Lightly Mapped

2 = Moderately Mapped

3 = Strongly Mapped

Unit I	Introduction
Local	-
Regional	-
National	-
Global	classification and properties related to the polymers.
Employability	classification and properties related to the polymers.
Entrepreneurship	Entrepreneurship; Team work/ Creativity by designing research problem
Skill Development	Disciplinary knowledge; Research related skills; scientific skills,
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	polymeric structure and property relationship
Local	-
Regional	-
National	-
Global	polymeric structure and property relationship
Employability	Student centric methods, such as experiential learning, participative learningand problem-solving methodologies (2.3.1)
Entrepreneurship	Entrepreneurship; Team work/ Creativity by designing research problem
Skill Development	Disciplinary knowledge; Research related skills; scientific skills,
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.

Unit III	Polymerization Chemistry
Local	-
Regional	-
National	-
Global	stereochemistry of polymerization reactions
Employability	Student centric methods, such as experiential learning, participative learning and problem-solving methodologies (2.3.1)
Entrepreneurship	Entrepreneurship; Team work/ Creativity by designing research problem
Skill Development	Disciplinary knowledge; Research related skills; scientific skills,
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Characterization of Polymers
Local	-
Regional	-
National	-
Global	various experimental techniques to identify and characterize polymers
Employability	Student centric methods, such as experiential learning, participative learningand problem-solving methodologies (2.3.1)
Entrepreneurship	Entrepreneurship; Team work/ Creativity by designing research problem
Skill Development	Disciplinary knowledge; Research related skills; scientific skills,
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Acquire relevant skills, includingtechnical and vocational skills, for employment,decent jobs and entrepreneurship (SDG 4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India’s ; India's Higher Education System (9.1- 9.3) develop good,thoughtful, well-rounded, and creative individuals (9.1.1);Towards a More Holistic and Multidisciplinary Education11.1- 11.13)
POE/4th IR	Technical Skills that match Industry Needs, Focus on Employability Skills (Local/Regional and Global)Team Work/

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Methods
Week 1	Introduction to Polymers	Textbook 1: D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition Elsevier Scientific, Publishing Company	Lecture, Discussion
Week 2	Polymer Structure and Classification	Textbook 1: D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition Elsevier Scientific, Publishing Company	Lecture, Group Work
Week 3	Polymerization Process	Textbook 1: D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition Elsevier Scientific, Publishing Company	Lecture, Case Studies
Week 4	Degree of Polymerization	Textbook 1: D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition Elsevier Scientific, Publishing Company	Lecture, Problem Solving

Week 5	Condensation Polymers	Textbook 1: D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition Elsevier Scientific, Publishing Company	Lecture, Hands-on Activities
Week 6	Addition Polymers	Textbook 1: D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition Elsevier Scientific, Publishing Company	Lecture, Demonstrations
Week 7	Molecular Weight & Polydispersity	Textbook 2: J.E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt,1996. Reference 3: J.R.Fried, Polymer	Lecture, Interactive Quizzes
Week 8	Crystallinity in Polymers	Textbook 2: J.E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt,1996. Reference 4: Billmeyer Jr.; Fred W.,	Lecture, Peer Discussions
Week 9	Melting Temperature & Glass Transition	Textbook 2: J.E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt,1996. Reference 1: Odian; George,	Lecture, Virtual Lab

Week 10	Volumetric Properties	Textbook 2: J.E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt,1996. Reference 3: J.R.Fried, Polymer	Lecture, Video Presentations
Week 11	PVT Relationship & Cross-linking	Textbook 3: Reaction Engineering of Step Growth Polymerization, S K Gupta and Anil Kumar, Plenum Press, 1987. OER 11:	Lecture, Problem-based Learning
Week 12	Industrial Polymerization Methods	Textbook 3: Reaction Engineering of Step Growth Polymerization, S K Gupta and Anil Kumar, Plenum Press, 1987. Reference 2: W.	Lecture, Case Studies
Week 13	Stereochemistry of Polymers	Reference 1: Odian; George, Principles of Polymerization, McGraw-Hill Book Co., New York(1970). OER 13: YouTube - Various	Lecture, Guest Lecture from an Expert
Week 14	Characterization of Polymers	Reference 2: W. Billmeyer, Text book of polymer science, 3rd Edn., 2007, Wiley. Reference 3: J.R.Fried, Polymer Science and	Lecture, Lab Experiments

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning Outcomes (CLOs)	Teaching-Learning Activities	Assessment Task Methods
I	• Understand the basic concepts of polymers and their classification. • Explain the polymerization process and its kinetics. • Analyze the differences between condensation and addition polymers. • Evaluate the degree of polymerization and its significance.	• Lecture on Introduction to Polymers and their examples • Case studies on polymerization processes • Group discussions on condensation and addition polymers • - Problem-solving sessions on degree of polymerization	• Quiz on polymer concepts • Written exam on polymerization kinetics • Assignment on condensation vs. addition polymers • - Lab report on measuring degree of polymerization
II	• Describe the structure of polymers and their property relationships. • Understand the molecular weight and polydispersity of polymers. • Analyze the volumetric properties and PVT relationship in polymers. • Explain the significance of crystallinity in polymer materials.	• Lectures on polymer structures and their properties • Interactive quizzes on molecular weight and polydispersity • Peer discussions on volumetric properties • - Virtual lab on determining crystallinity in polymers	• Test on polymer structure and property relationships • Class presentations on polydispersity in polymers • Lab experiment on PVT relationship in polymers • - Report on the influence of crystallinity on properties

III	• Understand the industrial methods of polymerization. • Analyze the stereochemistry of polymers and stereo-specific polymerization. • Evaluate the utility of catalysts in polymer manufacture. • Compare different catalysts used in polymer synthesis.	• Lectures on bulk, solution, emulsion, suspension methods • Guest lecture on stereochemistry in polymers • Problem-based learning on catalysts in polymerization • - Case studies on Zieglar-Natta, Metallocene catalysts	• Quiz on industrial polymerization methods • Written exam on stereo-specific polymerization • Presentation on modern catalysts in polymerization • - Comparative analysis of various polymer catalysts
IV	• Apply spectroscopic techniques for polymer characterization. • Analyze the molecular weight determination methods in polymers. • Demonstrate the understanding of end-group analysis in polymers. • Evaluate the importance of gel permeation chromatography.	• Lab experiments on FTIR, UV-visible, NMR spectroscopy • Group work on light scattering and osmometry methods • Video presentations on end-group analysis techniques • - Class discussions on GPC applications and limitations	• Lab report on polymer characterization techniques • Presentation on various molecular weight methods • Assessment based on video presentations • - GPC data analysis and interpretation

SCCH459	**Polymer Chemistry Practicals**	L	T	P	C
Version 3.0		0	0	4	2
Total Contact Hours	**30**				

Pre-requisites/Exposure	Basics of Chemistry
Co-requisites	--

Course Objectives

1. To learn the necessary calculations to get the viscosity value from the time of flow.
2. To carry out free radical solution polymerisation reactions.
3. To understand the theory and protocol of emulsion polymerization.
4. To observe and learn common characterizing techniques for polymers.

Course Outcomes

On completion of this course, the students will able to

CO1: describe the principles of free radical solution polymerization

CO2: compare and contrast the preparation methods of phenol-formaldehyde resins and explain the factors influencing the reaction.

CO3: apply their knowledge of viscometer principles to determine the molecular weight of known polymers using a viscometer.

CO4: analyse and interpret the results obtained from FTIR/TGA/DSC experiments to characterize polymers.

Catalog Description

This course imparts the basic experiments related to the field of polymer chemistry. It enables the students to calculate the molecular weight of any given polymer. The course helps them in understanding different types of polymerization, like free radical and emulsion polymerization. The course introduces the basic concepts about resins, their synthesis and the determination of their exchange capacities.

Course Content

List of Experiments

1. Free radical solution polymerization of any one: Styrene, methylmethacrylate, methyl acrylate, methacrylic acid (using free radical initiators). (purification of monomer should be
taught)
2. Preparation of phenol-formaldehyde resins
3. Emulsion polymerization of polymethylmethacrylate.
4. Use of viscometer for molecular weight determination – (any known polymer, example: polyvinyl pyrrolidone in water/polyacrylamide in $NaNO_2$solution) by viscometry. (students should be explained regarding principles and use of ubblohde/ostwald viscometer).
5. Estimation of amount of HCHO in a given solution by sodium bisulphite method.
6. Use of FTIR/TGA/DSC – for polymer characterization (may be demonstrated to students)
7. Determination of exchange capacity of cation exchange resins and anion exchange resins.

Recommended Books/Reference books

1.P. Munk & T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nd ed. John Wiley & Sons (2002).
2.M.P. Stevens, *Polymer Chemistry: An Introduction* 3rd ed. Oxford University Press (2005).

3. L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed. John Wiley & Sons(2005)

Open Educational Resources (OER)

- https://ocw.mit.edu/courses/chemistry/5-61-physical-chemistry-fall-2007/
- https://www.khanacademy.org/science/organic-chemistry
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3334372/
- https://nsdl.oercommons.org/courseware/module/27921/overview
- https://www.open.edu/openlearn/science-maths-technology/introduction-polymers/content-section-0
- http://chemcollective.org/vlab/291
- https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Electrochemistry/Electrochemical_Processes/Redox_Chemistry/Solubility_and_Complex-Ion_Equilibria/Chelation_and_Chelating_Agents/Ion-Exchange_Resins
- https://www.opencourselibrary.org/course/analytical-chemistry/
- https://www.coursera.org/learn/polymer-science-engineering
- https://openstax.org/details/books/chemistry

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Conduct of Experiment	Lab Record/ Quizzes/ Viva-voice	Attendance	End Term Practical Examination
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course Code and Title	Course Outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SCCH459 POLYMER CHEMISTRY PRACTICALS	CO1	3	2	2	1	1	2	1	2	2	1	3	1	1	1
	CO2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	CO3	2	2	1	1	1	2	1	2	2	1	2	1	1	1
	CO4	2	2	1	1	1	2	1	2	2	1	2	3	1	1

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit	-
Local	-
Regional	-
National	-
Global	-
Employability	Choice Based Credit System having field projects / research projects / internships (1.3.4) Courses on employability/ entrepreneurship/ skill development (1.1.3); Student centric methods, such as experiential

	learning, participative learning and problem-solving methodologies (2.3.1)
Entrepreneurship	Entrepreneurship; Team work/ Creativity by designing research problem
Skill Development	Disciplinary knowledge; Research related skills; scientific skills,
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Acquire relevant skills, includingtechnical and vocational skills, for employment,decent jobs and entrepreneurship (SDG 4.4)
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3) develop good,thoughtful, well-rounded, and creative individuals (9.1.1);Towards a More Holistic and Multidisciplinary Education (11.1- 11.13)
POE/4th IR	Technical Skills that match Industry Needs;Focus on Employability Skills (Local/Regional and Global)Team Work, Technology Use and Integration (23.1-23.13), Internship Program; Consulting Field ProjectsSkill Embedded Courses DevelopmentEmployabilityEntrepreneurship

Teaching Plan:

Weekly Teaching Pl...	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]- Ch...	Teaching-Learning M...
Week 1	Introduction to Polymers	Munk & Aminabhavi, Ch. 1	Lecture, Discussion
Week 2	Polymer Structure and Properties	Munk & Aminabhavi, Ch. 2	Lecture, Lab
Week 3	Polymerization Mechanisms	Stevens, Ch. 1	Lecture, Lab, Discussion
Week 4	Free Radical Polymerization	Stevens, Ch. 2	Lecture, Lab, Discussion
Week 5	Step-Growth Polymerization	Stevens, Ch. 3	Lecture, Lab, Discussion
Week 6	Copolymerization and C...	Munk & Aminabhavi, Ch. 3-4	Lecture, Lab, Discussion
Week 7	Polymer Characterization T...	Sperling, Ch. 1-2	Lecture, Lab, Discussion

Week 8	Molecular Weight Determination	Sperling, Ch. 3	Lecture, Lab, Discussion
Week 9	Thermal Analysis of Polymers	Sperling, Ch. 4	Lecture, Lab, Discussion
Week 10	Polymer Spectroscopy	Sperling, Ch. 5	Lecture, Lab,
Week 11	Introduction to Polymer Rheology	Munk & Aminabhavi, Ch. 5	Lecture, Lab,
Week 12	Polymer Blends and Composites	Stevens, Ch. 4	Lecture, Lab,
Week 13	Environmental Impact of Polymers	Stevens, Ch. 5	Lecture, Discussion
Week 14	Future Trends in Polymer Chemistry	Munk & Aminabhavi, Ch. 6	Lecture, Discussion

Facilitating the Achievement of Course Learning Outcomes

1	Understand the principles of free radical polymerization.	Lecture on free radical polymerization mechanism, Initiator types, Monomer purification techniques, Laboratory	In-class discussions, Q&A sessions, Homework assignments, Lab
2	Learn the synthesis principles of phenol-formaldehyde resins.	Lab sessions with hands-on practice in preparing phenol-formaldehyde resins, understanding reaction conditions, and	Lab reports, Observations during synthesis, Assessments.
3	Conduct the emulsion polymerization of polymethylmethacrylate.	Practical sessions involving the emulsion polymerization of polymethylmethacrylate, hands-on experience with	Group discussions, Experiment analysis, Concept application.
4	Apply viscometry to determine molecular weights of known polymers.	Hands-on sessions demonstrating the use of viscometers to measure molecular weights of polymers, using examples	Practical assessments, Accuracy in measurements.

SCCH409	**Environmental Chemistry**	L	T	P	C
Version 1.0		3	1	0	4

Total Contact Hours	60
Pre-requisites/Exposure	Basics of Environment
Co-requisites	--

Course Objectives

1. To aware the students about four spheres of environment.
2. To learn the students about different types of pollution and their impact on environment.
3. Demonstrate knowledge of chemical and biochemical principles of fundamental environmental processes in air, water, and soil.
4. Communicate environmental concerns and awareness to audiences in relevant formats in a straightforward and professional manner.

Course Outcomes

On completion of this course, the students will be able to

CO1. Recognize different types of toxic substances & responses and analyze toxicological information.
CO2. Apply basic chemical concepts to analyze chemical processes involved in different environmental problems (air, water & soil).
CO3. Describe water purification and waste treatment processes and the practical chemistry involved.
CO4. Describe causes and effects of environmental pollution by energy industry and discuss some mitigation strategies.
CO5. Explain energy crisis and different aspects of sustainability.

CO6. Discuss local and global environmental issues based on the knowledge gained throughout the course.

Catalog Description
This course imparts the knowledge of composition of atmosphere and biogeochemical cycle of major nutrients like C, N, P, S and O system. The course introduces analytical methods for determination of heavy metals present in water. This course helps them to get an idea of adverse

effect of industrialization, population and degradation of natural resources on the environment due to which concentration of greenhouse gases, air pollutant is increasing.

Course Content

UNIT I **15 Lecture**

Environment:

Composition of atmosphere, temperature variation of earth atmospheric system (temperature vs. altitude curve), biogeochemical cycles of C, N, P, S and O system.

UNIT II **15 Lectures**

Hydrosphere:

Hydrological cycle, aquatic pollution and water quality parameters – Dissolve oxygen, biochemical oxygen demand, chemical oxygen demand, Analytical methods for the determinationfluoride,chromiumandarsenic,residualchlorineandchlorinedemand,purification and treatment of municipal water and waste water.

UNIT III **15 Lectures**

Atmosphere:

Chemicalcompositionofatmosphere–particle,ions,andradicalsintheirformation,chemicaland photochemicalreactionsinatmosphere,smogformation,oxidesofN,C,S,andOandtheireffect, pollution by chemicals, CFC, Green House effect, acid rain, air pollution andcontrol.

UNIT IV **15 Lectures**

Aquatic chemistry:

Water and its necessities, various water quality parameters (DO, BOD, COD, conductivity,pH, alkalinity,hardness)anditsdetermination,Industrial,municipalwatertreatmentprocesses,Waste watertreatmentprocedure(primary,secondaryandtertiary),Solidwastetreatment.Soilpollution and Noisepollution.

Recommended Books/References:

1. De.A.K.Environmental Chemistry, Wiley Eastern Ltd,1990.
2. Miller T.G.Jr., Environmental Science, Wadsworth publishing House, Meerut Odum.E.P.1971.
3. Odum, E.P. (1971) Fundamentals of Ecology. Third Edition, W.B. Saunders Co., Philadelphia
4. S. E. Manahan, Environmental chemistry, 1993, Boca Raton, Lewis publisher
5. Environmental chemistry, Sharma and Kaur, 2016, Krishnapublishers
6. Environmental Pollution, Monitoring and control, S.M. Khopker, 2007, New Age International.

7. Environmental chemistry, C. Baird, M. Cann, 5th Edn, 2012, W.H.Freemanpublication.
9 G. S. Sodhi Fundamental Concepts of Environmental Chemistry (Third Edition) Narosa(2009).
10. Principles of instrumental analysis: D. A. Skoog, Fifth Edition, Sauns College Publishing (London)
11 Basic concepts of analytical chemistry: S. M. Khopkar, Wiley Eastern(1995)

Open Educational Resources (OER)

- https://www.khanacademy.org/
- https://www.coursera.org/
- https://ocw.mit.edu/
- https://www.epa.gov/students
- https://www.unep.org/learning/
- https://en.wikibooks.org/wiki/Environmental_Science
- https://www.noaa.gov/education

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Attendance	Quiz/Assignment/	Mid Term	End Term
Weightage (%)	10	20	20	50

Course Code and Title	Course Outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SCCH409 Enviromental Chemistry	CO1	3	2	2	1	1	2	1	2	2	1	3	1	1	1
	CO2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	CO3	2	2	1	1	1	2	1	2	2	1	2	1	1	1
	CO4	2	2	1	1	1	2	1	2	2	1	2	3	1	1

1=weakly mapped

2= moderately mapped
3=strongly mapped

Unit I	Environment
Local	-
Regional	-
National	-
Global	Composition of atmosphere
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit II	Hydrosphere
Local	-
Regional	-
National	-
Global	Hydrological cycle, aquatic pollution and water quality parameters
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit III	Atmosphere
Local	-
Regional	-
National	-
Global	Chemical composition of atmosphere
Employability	-

Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit IV	Aquatic chemistry
Local	-
Regional	-
National	-
Global	water quality parameters (DO, BOD, COD
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
SDG	Skill for Decent Work; Sustainable Development and Global Citizenship
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3), Promoting High Quality research (18.1-18.9); Technology Use and Integration (23.1-23.13)
POE/4th IR	Awareness of Local and Global environmental issues; Case Studies and minor project or training of online data analysis/*Exposure towards digitalization of data. *Exposure towards Checking of AQI (Air quality index) * Environmental problems/issues and remedies (such as crop optimization, disease track etc.) by AI

Teaching Plan:

Week	Topics	Reference Materials	Teaching/Learning Methods
Week 1	Introduction to Environmental Chemistry	Textbook: 1	Lecture, Discussion
Week 2	Composition of Earth's Atmosphere	Textbook: 1	Lecture, Visual Aids
Week 3	Temperature Variation of Atmosphere	Textbook: 1	Lecture, Charts, Diagrams
Week 4	Biogeochemical Cycles of C, N, P, S, O	Textbook: 2, 3	Lecture, Case Studies
Week 5	Hydrological Cycle	Textbook: 2	Lecture, Multimedia Resources
Week 6	Aquatic Pollution	Textbook: 2	Lecture, Case Studies
Week 7	Water Quality Parameters	Textbook: 2	Lecture, Laboratory Demonstrations
Week 8	Analytical Methods for Water Analysis	Textbook: 11, Open Education Resources	Lecture, Practical Exercises
Week 9	Air Composition and Chemical Reactions	Textbook: 1, 4	Lecture, Group Discussions
Week 10	Air Pollution and Control	Textbook: 4, 7	Lecture, Case Studies
Week 11	Greenhouse Effect and Acid Rain	Textbook: 4, 7	Lecture, Multimedia Presentations
Week 12	Aquatic Chemistry and Water Quality	Textbook: 2, 5	Lecture, Problem-Solving Exercises
Week 13	Water Treatment Processes	Textbook: 6	Lecture, Site Visits (if possible)
Week 14	Soil and Noise Pollution	Textbook: 5, 8	Lecture, Student Presentations

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning Outcomes (CLOs)	Teaching Learning Activities	Assessment Task Methods

Unit I: Environment	1. Understand the composition of the Earth's atmosphere and its significance. 2. Analyze the temperature variation in the Earth's atmospheric system.	- Lecture and discussion on atmosphere composition. - Visual aids, charts, and diagrams to explain temperature variations. - Case studies	- Written examination on atmospheric composition and importance. - Quizzes and class participation assessing understanding. - Research paper or
Unit II: Hydrosphere	1. Describe the hydrological cycle and its role in the hydrosphere. 2. Identify and assess aquatic pollution and water quality parameters. 3. Apply analytical methods for	- Lectures and multimedia resources on the hydrological cycle. - Laboratory demonstrations and water quality parameter analysis.	- Class assignments and quizzes on the hydrological cycle. - Lab reports and practical assessments. - Practical tests and hands-on assessments. - Written
Unit III: Atmosphere	1. Understand the chemical composition of the atmosphere. 2. Analyze chemical and photochemical reactions in the atmosphere. 3. Explain the causes and	- Lectures and discussions on atmospheric chemistry. - Group discussions and case studies on atmospheric reactions. - Multimedia presentations	- Written examination on atmospheric composition. - Research projects on specific atmospheric reactions. - Class presentations on air
Unit IV: Aquatic Chemistry and Pollution	1. Identify various water quality parameters and their significance. 2. Evaluate industrial and municipal water treatment processes. 3. Analyze solid waste	- Lectures and practical exercises on water quality parameters. - Guest lectures and discussions on treatment methods. - Case studies and group	- Class assignments and quizzes on water quality parameters. - Group projects on designing treatment systems. - Research reports on solid

SCCH461	**Enviromental Chemistry Practicals**	L	T	P	C
Version 1.0		0	0	4	2
Contact Hours	30				
Pre-requisites/Exposure	Basics of water quality parameters				

Co-requisites	--

Course Objectives

1. To introduce water quality parameters like COD, BOD, DO.
2. To learn about determination of water quality parameters.
3. To determine the %age of chlorine in bleaching powder.
4. To determine alkalinity of water sample.
5. Performing risk assessment of chemical experiments and chemical analytical activity

Course Outcomes

On completion of this course, the students will be able to

CO1. Understand the basic principles involved in analytical techniques.

CO2. Describe water purification and waste treatment processes and the practical chemistry involved.

CO3. Enable how to communicate scientific information clearly and accurately, both in oral and in written forms.

CO4. Students will learn to think analytically and assess information in such ways to make informed conclusions and decisions about controversial environmental issues.

CO5. Learn to work with others as part of a team to solve scientific problems.

CO6. Trained in analytical and instrumental skills required for environmental monitoring of pollutants.

Catalog Description

This course covers some simple methods for determination water quality parameter like COD, BOD, and DO. The course also gives hand on experience for determination of some major anions present in water sample.

Course Content

List of suggested laboratory practical

Determination of water quality parameters in following aspect:

1. Determination of dissolved oxygen in given water (chemical method/instrumentation method).

2.Determination of Biological Oxygen Demand (BOD_5).

3. Determination of Chemical Oxygen Demand(COD).

4. Finding out percentage of available chlorine in bleachingpowder.

5. Measurement of chloride, sulphate and salinity of water samples by titration method ($AgNO_3$ and potassiumchromate).

6. Estimation of total alkalinity of water samples (carbonate, bicarbonate) by titrationmethod.

7. Estimation of SPM in airsamples.

List of Recommended books/Reference Books:

1. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, John Wiley & Sons, Inc. Publishers, New Delhi.(2005 edition).
3. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, NewDelhi.
4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. NewDelhi.
5. A. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, NewDelhi.
6. S. M. Khopkar, *Environmental Pollution Analysis*: New Age Int. Publisher, NewDelhi.

(The list of experiments and books are purly suggestive; University/institute may incorporate further changes in number of experiments and books/refererences (updated version from time to time) based on course design and available infrastructure facilities).

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.

Open Educational Resources (OER)

- https://www.khanacademy.org/
- https://www.coursera.org/
- https://ocw.mit.edu/
- https://www.epa.gov/students
- https://www.unep.org/learning/
- https://en.wikibooks.org/wiki/Environmental_Science
- https://www.noaa.gov/education

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Compone	**Conduct of**	**Lab**	**Attendance**	**End Term**
Weightage	**20**	**20**	**10**	**50**

Cour se Code	**C o u**	**P O 1**	**P O 2**	**P O 3**	**P O 4**	**P O 5**	**P O 6**	**P O 7**	**P O 8**	**P O 9**	**P O 1**	**P S O**	**P S O**	**P S O**	**P S O**
SCC H461	**C O 1**	**3**	**2**	**2**	**1**	**1**	**2**	**1**	**2**	**2**	**1**	**3**	**1**	**1**	**1**

ENVIRONMENTAL CHEMISTRY PRA	**CO2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
	CO3	**2**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**2**	**1**	**2**	**1**	**1**	**1**
	CO4	**2**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**2**	**1**	**2**	**3**	**1**	**1**

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit	Methods for determination water quality parameter like COD, BOD, and DO.
Local	-
Regional	-
National	-
Global	determination water quality parameter like COD, BOD, and DO
Employability	-
Entrepreneurship	-
Skill Development	The course also gives hand on experience for determination of some major anions present in water sample.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
SDG	Skills for Decent Work (SDG 4.4), Sustainable Development and Global Citizenship (SDG 4.7), Ensure availability and sustainable management of water and sanitation for all (SDG 6); Promote peaceful and inclusive societies for sustainable development,
NEP	Learning should be holistic, integrated, enjoyable and engaging; Quality Universities and Colleges: A New and Forward-looking Vision for India’s ; India's Higher Education

	System (9.1- 9.3)Towards a More Holistic and Multidisciplinary Education (11.1- 11.13), Promoting High Quality Research (18.1-18.9)
POE/4th IR	Technical Skills that match Industry Needs;Focus on Employability Skills (Local/Regional and Global)Team Work, Technology Use and Integration (23.1-23.13), Internship Program

Teaching Plan:

Week	Topic	Textbook/Reference Books	Teaching/Learning Methods
1	Introduction to Chemistry	Textbook: 5	Lectures, Discussions
2	Atoms and Elements	Textbook: 1	Lectures, Laboratory
3	Chemical Bonds and Compounds	Textbook: 1	Lectures, Problem-solving
4	Chemical Reactions	Textbook: 1	Lectures, Laboratory
5	Stoichiometry and Mass Balances	Textbook: 1	Lectures, Problem-solving
6	Chemical Thermodynamics	Textbook: 1	Lectures, Discussions
7	Chemical Kinetics	Textbook: 1	Lectures, Laboratory
8	Phase Equilibrium and Solutions	Textbook: 1	Lectures, Problem-solving
9	Acids and Bases	Textbook: 5	Lectures, Discussions
10	Electrochemistry	Textbook: 1	Lectures, Laboratory
11	Environmental Chemistry	Textbook: 5	Lectures, Problem-solving
12	Industrial Chemistry	Textbook: 3, 4	Lectures, Discussions
13	Polymers and Materials	Textbook: 2	Lectures, Problem-solving
14	Review and Exam Preparation	Textbook: 1, 2, 3, 4, 5	Review sessions, Exams

Facilitating the Achievement of Course Learning Outcomes

Unit	Learning Outcome	Teaching Learning Activities	Assessment Task Methods
1	Determine dissolved oxygen in water.	- Lectures on chemical and instrumentation methods.	- Practical exams with real water samples.
2	Determine Biological Oxygen Demand (BOD5).	- Lectures on BOD principles and measurement.	- BOD sample analysis reports.
3	Determine Chemical Oxygen Demand (COD).	- Lectures on COD analysis and reagents.	- COD sample analysis reports.
4	Find out the percentage of available chlorine in water.	- Lectures on chlorine determination methods.	- Practical exams on chlorine analysis.

SCCH411	**Analytical Techniques of Chemistry**	L	T	P	C
Version 2.0		3	1	0	4
Contact Hours	60				
Pre-requisites/Exposure	Basics of Analytics techniques				
Co-requisites	--				

Course Objectives

1. Familiarize with fundamental of analytical chemistry.
2. To establish an appreciation of the role of chemistry in quantitative analysis.
3. To provide experience in some scientific methods employed in analytical chemistry.

4. To develop some understanding of the professional and safety responsibilities residing in working on chemical analysis.

Course Outcomes

On completion of this course, the students will be able to

CO1. Know about the principles and applications of modern chemical instrumentation, experimental design, and data analysis.
CO2. Acquire the knowledge of the underlying chemical and physical of instrumental methods of analysis, including electronic and vibrational spectroscopy, UV-Visible spectroscopy, and electro-analytical techniques.
CO3. Enable students to communicate scientific information clearly and accurately, both in oral and in written forms and apply the concepts to analyze data
CO4. Idea about the composition of written laboratory reports that summarize experimental procedures and the accurately present and interpret data.
CO5. Learn to work with others as part of a team to solve scientific problems
CO6. Interpret results of different gravimetric analysis methods

Catalog Description

This course introduces analytical chemistry and an overview of important analytical methods and their range of application within detection of inorganic and organic compounds. Important analytical quantitative techniques from classical methods, electrochemical methods, spectrochemical / spectrophotometric methods, and separation techniques are reviewed. As a part of this course, a project work is also to be carried out; relevant topics will be announced at semester start. There will be an excursion at the end of the semester.

Course Content

UNIT I **15 Lectures**

Qualitative and quantitative aspects of analysis:

Tools in analytical chemistry and their applications, Sampling, evaluation of analytical data, errors, accuracy and precision, statistical test of data; F, Q and t-test, rejection of data, and confidence intervals.

UNIT II **15 Lectures**

Spectroscopy:

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

Vibration spectroscopy: Basic principles of instrumentation, sampling techniques. Application of IR spectroscopy for characterization through interpretation of data, Effect and importance of isotope substitution. Introduction to Raman spectra

UV-Visible Spectrometry: Basic principles of instrumentation, principles of quantitative analysis using estimation of metal ions from aqueous solution, Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

UNIT III **10 Lectures**

Thermal analysis:

Theory of thermogravimetry (TG and DTG), instrumentation, estimation of Ca and Mg from their mixture.

Electroanalytical methods: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. determination of pKa values.

UNIT IV **20 Lecture**

Separation techniques:

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non- aqueous media. Chromatography techniques: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis using LC, GLC, TLC and HPLC.

Recommended Books/Reference Books:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing California, USA, 1988.
3. Christian, G.D, Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.: Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
5. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Saunder College Publications, (1998).
6. Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood John Wiley 1979.

7. Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.
8. Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition)1998
9.Skoog D.A., Holler F.J., Nieman T.A., Principles of instrumental analysis, 5th Edn., Brooks & Cole (1997).

Open Educational Resources (OER)

- https://openstax.org/
- http://sdbs.db.aist.go.jp/
- https://www.knovel.com/web/portal/basic_search/display?_EXT_KNOVEL_DISPLAY_=on&SEARCH_IDENTIFIER=TP%7CORR000132
- http://chem.libretexts.org/Bookshelves/Analytical_Chemistry
- https://ocw.uci.edu/courses/chem_201a_quantitative_chemical_analysis.html
- http://www.chemguide.co.uk/
- https://edu.rsc.org/
- https://www.khanacademy.org/science/chemistry

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Attendance	Quiz/Assignment/	Mid Term	End Term
Weightage (%)	10	20	20	50

Course Code and Title	Course Outcome (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
SCCH411	CO1	3	1	1	3	3	2	1	1	1	2	3	3	1	2

Analytical Techniques of Chemistry	**CO2**	**2**	**3**	**1**	**2**	**1**	**2**	**1**	**2**	**2**	**2**	**1**	**1**	**1**	**1**
	CO3	**1**	**1**	**2**	**1**	**2**	**2**	**1**	**2**	**2**	**1**	**1**	**1**	**2**	**2**
	CO4	**1**	**1**	**1**	**3**	**2**	**3**	**1**	**1**	**1**	**2**	**2**	**2**	**1**	**3**
	CO5	**2**	**1**	**2**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**3**	**3**	**2**	**2**
	CO6	**1**	**2**	**1**	**2**	**2**	**3**	**1**	**3**	**2**	**1**	**2**	**1**	**2**	**1**

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	Qualitative and quantitative aspects of analysis
Local	-
Regional	-
National	-
Global	-
Employability	-
Entrepreneurship	-
Skill Development	Important analytical quantitative techniques from classical methods, electrochemical methods, spectrochemical / spectrophotometric methods, and separation techniques are reviewed.
Professional Ethics	-
Gender	-

Human Values	-
Environment & Sustainability	-
Unit II	Spectroscopy
Local	-
Regional	-
National	-
Global	-
Employability	-
Entrepreneurship	-
Skill Development	Important analytical quantitative techniques from classical methods, electrochemical methods, spectrochemical / spectrophotometric methods, and separation techniques are reviewed.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	Thermal analysis
Local	-
Regional	-
National	-
Global	-
Employability	-
Entrepreneurship	-
Skill Development	Important analytical quantitative techniques from classical methods, electrochemical methods, spectrochemical / spectrophotometric methods, and separation techniques are reviewed.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	Separation techniques
Local	-
Regional	-
National	-
Global	Important analytical quantitative techniques from classical methods,

	electrochemical methods, spectrochemical / spectrophotometric methods, and separation techniques are reviewed.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	India's Higher Education System (9.1- 9.3), Promoting High Quality research (18.1-18.9); Technology Use and Integration (23.1-23.13)
POE/4th IR	Global Education Knowledge, Technical Skill that match Industry Needs, Focus on Emloyability Skills (Regional/ Global), Internship Program, On Campus Job

Teaching Plan:

Weekly teaching plan	Topic /Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Methods
Week1	Qualitative and Quantitative Analysis	Textbook: Vogel's Quantitative Chemical Analysis	Lectures, Introduction to the course, Syllabus review
Week 2	Sampling and Data Evaluation	Textbook: Vogel's Quantitative Chemical Analysis	Lectures, Group Discussions, Case Studies
Week 3	Errors and Statistical Analysis	Textbook: Harris - Exploring Chemical Analysis	Lectures, Problem-Solving, Practice Questions
Week 4	Spectroscopy: Basics and Principles	Textbook: Skoog et al. - Principles of Instrumental Analysis	Lectures, Visual Aids, Interactive Demonstrations
Week 5	UV-Visible Spectrometry	Textbook: Willard et al. - Instrumental Methods of Analysis	Lectures, Hands-on UV-Vis Spectrometer Practice

Week 6	Vibration Spectroscopy	Textbook: Christian - Analytical Chemistry	Lectures, Case Studies, Guest Speaker (if available)
Week 7	Thermal Analysis	Textbook: Vogel's Quantitative Chemical Analysis	Lectures, Lab Demonstrations, Hands-on Experiments
Week 8	Electroanalytical Methods	Textbook: Harris - Exploring Chemical Analysis	Lectures, Problem-Solving, Workshops
Week 9	pH Metric and Potentiometric Titrations	Textbook: Skoog et al. - Principles of Instrumental Analysis	Lectures, Group Discussions, Simulation Activities
Week 10	Conductometric Titrations	Textbook: Harris - Exploring Chemical Analysis	Lectures, Hands-on Titrations, Lab Practice
Week 11	Solvent Extraction	Textbook: Khopkar - Basic Concepts of Analytical Chemistry	Lectures, Case Studies, Group Projects
Week 12	Chromatography Techniques	Textbook: Skoog et al. - Principles of Instrumental Analysis	Lectures, Lab Demonstrations, Interactive Workshops
Week 13	Chromatographic Methods	Textbook: Mikes - Laboratory Handbook of Chromatographic Methods	Lectures, Hands-on Chromatography, Problem-Solving
Week 14	Course Review and Assessment	Textbook: As appropriate	Review, Final Exam, Assessment

Facilitating the Achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching Learning Activity**	**Assessment Task Methods**

1	CLO1: Understanding qualitative aspects of analysis CLO2: Applying quantitative aspects of analysis CLO3: Evaluating Data and Errors CLO4: Applying Statistical Tests	Lectures, Discussions, Problem-Solving, Interactive Workshops, Case Studies Hands-on Lab Work, Experiments, Data Analysis, Simulation Activities, Data Interpretation	Quizzes, Class Participation, Homework Lab Reports, Lab Assessments, Lab Records Data Analysis Assignments, Midterm Exam
2	CLO1: Understanding spectroscopy basics and principles CLO2: Applying Spectroscopic Techniques CLO3: Analyzing Data from Spectroscopy Experiments CLO4: Interpretation and Application of Spectroscopic Data	Lectures, Visual Aids, Demonstration, Interactive Demonstrations, Multimedia Resources Hands-on Instrumentation Practice, Laboratory Experiments, Data Interpretation	Quizzes, Class Participation, Homework Lab Reports, Lab Assessments, Lab Records Data Analysis Assignments, Midterm Exam
3	CLO1: Understanding Thermal Analysis CLO2: Applying Electroanalytical Methods CLO3: Problem Solving in Analytical Chemistry CLO4: Application of Analytical Methods	Lectures, Hands-on Lab Demonstrations, Multimedia Resources, Interactive Experiments Lab Practice, Data Analysis, Simulation Activities Problem-Solving Sessions, Case Studies, Group Projects,	Quizzes, Class Participation, Homework Lab Reports, Lab Assessments, Lab Records Data Analysis Assignments, Midterm Exam
4	CLO1: Describe the principles and efficiency of solvent extraction. CLO2: Explain the mechanisms of separation in chromatography techniques. CLO3: Develop and optimize chromatographic methods. CLO4: Analyze the effectiveness of various separation techniques.	Workshops Guest Lectures, Real-World Applications, Research Papers, Software Tools	Quizzes and written assignments on chromatography mechanisms. - Analysis of chromatography simulations.

SCCH463	**Analytical Techniques of Chemistry Practicals**	L	T	P	C
Version 2.0		0	0	4	2
Contact Hours	30				
Pre-requisites/Exposure	Basics of chromatography and solvent extraction				
Co-requisites	--				

Course Objectives

1. To introduce some analytical techniques like flame photometer, infra-red spectrophotometer
2. To learn about determination of water quality parameters like COD, BOD and DO.
3. To analyse the composition of soil.
4. To learn about qualitative analysis of metal ions from binary mixture.
5. Performing risk assessment of chemical experiments and chemical analytical activity

Course Outcomes

On completion of this course, the students will be able to

CO1. Aware about the analytical techniques.

CO2. Determination of water quality parameter like COD, BOD and DO.

CO3. Enable to estimate Ca, Mg, phosphate and nitrate present in soil.

CO4. Learn to estimate Na, Ca, Li present in aerated drinks and fruit juice in such ways to make informed conclusions.

CO5. Learn to separate the metal ions, amino acids by chromatography.

CO6. Trained in analytical and instrumental skills required to give hand on experience.

Catalog Description

This course covers some simple methods for determination water quality parameter like COD, BOD, and DO, major ions present in soil and aerated drinks. The course also gives hand on experience of flame photometer, chromatography and spectrophotometry techniques.

Course Content

(Recommended to carry out at least two experiments from each section)

I.Chromatography:

i. Paper chromatographic separation of Fe^{3+}, Al^{3+}, andCr^{3+}.

ii. Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rfvalues.

iii. SeparateamixtureofSudanyellowandSudanRedbyTLCtechniqueandidentifythemonthe basis of their Rfvalues.

iv. Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. SolventExtractions:

i. ToseparateamixtureofNi^{2+}&Fe^{2+}bycomplexationwithDMGandextractingtheNi^{2+}-

DMG complex in chloroform, and determine its concentration byspectrophotometry.

ii. Determine the pH of the given aerated drinks fruit juices, shampoos andsoaps.

iii. DeterminationofNa,Ca,Liincoladrinksandfruitjuicesusingflamephotometrictechniques.

III. Analysis of soil:

i. Determination of pH ofsoil.

ii. Total solublesalt

iii. Estimation of calcium, magnesium, phosphate,nitrate

IV. Ionexchange:

i. Determination of exchange capacity of cation exchange resins and anion exchangeresins.

ii. Separation of metal ions from their binarymixture.

iii. Separation of amino acids from organic acids by ion exchangechromatography.

V. Spectrophotometry

i. Determination of pKa values of indicator using spectrophotometry.

ii. Structural characterization of compounds by infraredspectroscopy.

iii. Determination of dissolved oxygen inwater.

iv. Determination of chemical oxygen demand(COD).

v. Determination of Biological oxygen demand(BOD).

vi. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Recommended text books/references:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson,2009.
2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,1988.
3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York,2004.
4. Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.
5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher,2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition.
7. Mikes, O. & Chalmes, R.A. *Laboratory Handbook of Chromatographic &Allied Methods*, Elles Harwood Ltd.London.
8. Ditts, R.V. *Analytical Chemistry: Methods of separation.* Van Nostrand, NewYork, 1974.

(Note: A candidate has to perform at least eight experiments in the lab. Any suitable experiment may be added.)

Open Educational Resources (OER)

- https://www.chromacademy.com/
- https://byjus.com/chemistry/paper-chromatography/
- https://www.chemguide.co.uk/physical/complex/edta.html
- https://www.chemguide.co.uk/analysis/phcurve.html
- https://extension.uga.edu/publications/detail.html?number=B1183
- https://www.lenntech.com/library/ion-exchange/ion-exchange/ion-exchange.htm
- https://www.shimadzu.com/an/uv/support/spectro-tutorial/index.html
- https://soiltesting.tamu.edu/

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Conduct of	Lab	Attendance	End Term
Weightage	20	20	10	50

Course Outcome (CO)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	2	3	1	2	1	1	2	2	2	1	2	1
CO2	3	3	2	3	1	2	1	1	2	2	2	2	1	2
CO3	3	2	2	3	1	2	1	1	2	2	2	1	2	2
CO4	3	2	2	3	2	2	2	1	2	2	3	2	2	2

CO5	**2**	**3**	**2**	**1**	**1**	**3**	**1**	**2**	**2**	**2**	**2**	**1**	**2**	**2**
CO6	**2**	**2**	**3**	**1**	**1**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	I. Chromatography II. Solvent Extractions III. Analysis of soil IV. Ion exchange V. Spectrophotometry
Local	Analysis of soil Spectrophotometry chromatography
Regional	-
National	Solvent Extractions Ionexchange
Global	-
Employability	-
Entrepreneurship	-
Skill Development	This course covers some simple methods for determination water quality parameter like COD, BOD, and DO, major ions present in soil and aerated drinks. The course also gives hand on experience of flame photometer, chromatography and spectrophotometry techniques.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	This course covers some simple methods for determination water quality parameter like COD, BOD, and DO, major ions present in soil and aerated drinks.
SDG	Universal quality education and lifelong learning(SDG 4.4)
NEP	India's Higher Education System (9.1- 9.3), Promoting High Quality research (18.1-18.9); Technology Use and Integration (23.1-23.13)
POE/4th IR	Global Education Knowledge, Technical Skill, Focus on Employability Skills (Regional/ Global), Interenship Program,

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Method
Week 1	Introduction to Analytical Chemistry	Christian, G.D. - "Analytical Chemistry"	Lecture, Discussion, Reading Assignment
Week 2	Basic Concepts in Analytical Chemistry	Khopkar, S.M. - "Basic Concepts of Analytical Chemistry"	Lecture, Problem Solving, Q&A
Week 3	Sampling and Sample Preparation	Harris, D.C. - "Exploring Chemical Analysis"	Lecture, Lab Demonstration
Week 4	Gravimetric Analysis	Christian, G.D. - "Analytical Chemistry"	Lecture, Problem Solving, Lab Work
Week 5	Volumetric Analysis	Khopkar, S.M. - "Basic Concepts of Analytical Chemistry"	Lecture, Lab Work, Group Discussions
Week 6	Spectroscopic Methods	Skoog, D.A. et al. - "Principles of Instrumental Analysis"	Lecture, Case Studies, Q&A
Week 7	Chromatographic Techniques	Mikes, O. & Chalmes, R.A. - "Laboratory Handbook of Chromatographic & Allied Methods"	Lecture, Lab Work
Week 8	Instrumental Analysis	Willard, H.H. et al. - "Instrumental Methods of Analysis"	Lecture, Lab Work, Case Studies
Week 9	Quality Control and Assurance	Harris, D.C. - "Exploring Chemical Analysis"	Lecture, Group Discussions, Q&A
Week 10	Environmental Analysis	Christian, G.D. - "Analytical Chemistry"	Lecture, Case Studies, Lab Work
Week 11	Electroanalytical Methods	Skoog, D.A. et al. - "Principles of Instrumental Analysis"	Lecture, Problem Solving, Q&A
Week 12	Mass Spectrometry	Harris, D.C. - "Exploring Chemical Analysis"	Lecture, Lab Work, Group Discussions
Week 13	Separation Methods	Ditts, R.V. - "Analytical Chemistry: Methods of Separation"	Lecture, Lab Work, Case Studies
Week 14	Analytical Chemistry Applications	Mendham, J. - "Vogel's Quantitative Chemical Analysis"	Lecture, Group Discussions, Q&A

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching-Learning Activities	Assessment Task Methods

I	CLO1: Perform paper chromatography CLO2: Identify monosaccharides CLO3: Perform TLC separation CLO4: Perform TLC	Lecture on principles, demonstration of separation Conduct chromatography experiment, report Rf values Lecture on TLC and Rf values, hands-on practice Practical exercise on TLC separation	Practical examination (Separation) Lab report on Rf values Lab assessment based on Rf values Lab report on TLC separation
II	CLO1: Perform complexation extraction CLO2: Determine pH of various substances CLO3: Determine metal ion concentrations	Lecture on complexation and practical demonstration pH measurement experiments with various substances Instruction on flame photometry, metal ion analysis	Practical examination (Complexation) Lab report on pH determination Lab assessment on metal ion determination
III	CLO1: Determine soil pH CLO2: Analyze total soluble salt content CLO3: Estimate calcium, magnesium, etc.	Lecture on soil pH determination, pH measurement experiments Instruction on salt analysis techniques, total soluble salt analysis Practical exercises for estimating soil nutrient levels	Lab report on soil pH Lab assessment on salt analysis Lab report on nutrient estimation Practical examination (Exchange Capacity)
IV	CLO1: Determine exchange capacity CLO2: Separate metal ions CLO3: Separate amino acids	Lecture on ion exchange, practical demonstration of capacity determination Instruction on separation techniques, practical separation of metal ions Lecture on ion exchange chromatography, hands-on practice	Lab assessment on metal ion separation Lab report on amino acid separation Lab report on pKa determination
V	CLO1: Determine pKa values CLO2: Characterize compounds CLO3: Determine dissolved oxygen CLO4: Determine COD	Instruction on IR spectroscopy, compound characterization using IR spectroscopy Lecture on dissolved oxygen analysis, practical experiment Instruction on COD and BOD analysis, practical exercises	Lab assessment on compound characterization Lab report on dissolved oxygen determination Lab assessment on COD and BOD determination

MINOR (ENVIRONMENTAL SCIENCES)

UEV101	**EARTH AND EARTH SURFACE PROCESSES**	**L**	**T**	**P**	**C**
Version 3.0		**4**	**0**	**0**	**4**

Total Contact Hours	**60**
Pre-requisites/Exposure	**Earth and its processes**
Co-requisites	--

COURSE OBJECTIVES
The course will enable the student-teacher to:

1. Analyze Earth's geological history and its impact on landscapes.
2. Understand dynamic Earth processes and plate tectonics.
3. Identify minerals, rocks, and surface processes shaping the Earth's features.
4. Evaluate interactions between Earth's surface, atmosphere, and environmental changes.

COURSE OUTCOMES (CO)
On completion of this course, the student-teacher will be able to:

CO1: Understand Earth's Geological Evolution and Landscapes
CO2: Describe the processes of solar system formation, planetary differentiation, and cultural landscape development.
CO3: Classify minerals and rock-forming minerals, and understand the rock cycle, lithification, and metamorphism
CO4: Compare different types of rocks, weathering processes, erosion agents, and sediment transport mechanisms.

CATALOG DESCRIPTION
Explore the fascinating world of Earth science and geology in this comprehensive course. Delve into the history of our planet's formation, its dynamic processes, and the intricate interactions that have shaped its landscapes over millennia. Through a systematic study of Earth's geological evolution, plate tectonics, minerals, rocks, and surface processes, students will gain a deep understanding of the forces that have shaped the Earth's features. The course will also examine the Earth's atmosphere, its role in shaping landforms, and the environmental changes that have occurred over time. By delving into the importance of mountain systems and their influence on climates, civilizations, and ecosystems, students will develop a holistic perspective on Earth's complex history and its impact on our world today.

<u>COURSE CONTENT</u>
The paper will introduce students to the basic structure and composition of the Earth and will explore various surface processes and their impact on and role in living systems. It will also dealswiththeinteractiveprocessesin theinneras well as outer Earth's surface.

Unit1: History ofEarth (15lectures)
Solarsystemformationandplanetarydifferentiation;formationoftheEarth:formationandcomposition of core, mantle, crust, atmosphere and hydrosphere; chemical composition of Earth;geological time scale and major changes on the Earth's surface; Holocene and the emergence ofhumans,roleof humansin shapinglandscapes; developmentof culturallandscapes.

Unit2: Earth system processes (15lectures)
Movement of lithosphere plates; mantle convection and plate tectonics, major plates and hot spots,plate boundaries; sea floor spread; earthquakes; volcanic activities; orogeny; isostasy; gravitational andmagnetic fields of the earth; origin of the main geomagnetic field; continental drift, Pangaea andpresent-daycontinents,paleontologicalevidencesofplatetectonics;continentalcollisionandmountainformation with specificexampleof theHimalaya.

Unit3:Mineralsandrocks (10lectures)
Minerals and important rock forming minerals; rock cycle: lithification and metamorphism; Three rocklaws;rockstructure,igneous,sedimentaryandmetamorphicrocks;weathering:physical,biogeochemical processes; erosion: physical processes of erosion, factors affecting erosion; agents oferosion: rivers and streams, glacial and aeolian transportation and deposition of sediments by runningwater,wind and glaciers.

Unit4:Earthsurfaceprocesses (10lectures)
Atmosphere:evolutionofearth'satmosphere,compositionofatmosphere,physicalandopticalproperties, circulation; interfaces: atmosphere–ocean interface, atmosphere–land interface, ocean–landinterface; land surface processes: fluvial and glacial processes, rivers and geomorphology; types ofglaciers, glacier dynamics, erosional and depositional processes and glaciated landscapes; coastalprocesses.

Unit5:Importanceofbeing a mountain (10lectures)
Formation of Peninsular Indian mountain systems - Western and Eastern Ghats, Vindhyas, Aravallis,etc. Formation of the Himalaya; development of glaciers, perennial river systems and evolution ofmonsoon in Indian subcontinent; formation of Indo-Gangetic Plains, arrival of humans; evolution ofIndusValleycivilization;progressionofagricultureintheIndiansubcontinentinHolocene;withdrawing monsoon and lessons to draw.

SuggestedReadings

1. Bridge, J., & Demicco, R. 2008. *Earth Surface Processes, Landforms and Sediment deposits*.CambridgeUniversity Press.
2. Duff, P. M. D., & Duff, D. (Eds.). 1993. *Holmes' Principles of Physical Geology*. Taylor &Francis.
3. Gupta, A. K., Anderson, D. M., Pandey, D. N., & Singhvi, A. K. 2006. Adaptation and humanmigration, and evidence of agriculture coincident with changes in the Indian summer monsoonduringtheHolocene. *CurrentScience* **90:** 1082-1090.
4. Keller,E.A.2011.*Introduction toEnvironmental Geology* (5thedition).Pearson Prentice Hall.
5. Krishnan,M.S.1982. *GeologyofIndia andBurma*.CBS Publishers&Distributors.

6. Leeder,M.,Arlucea,M.P.2005.*PhysicalProcessesinEarthandEnvironmentalSciences.* BlackwellPublishing.
7. Pelletier, J. D. 2008. *Quantitative Modeling of Earth Surface Processes* (Vol. 304). Cambridge:CambridgeUniversity Press. Chicago

Open Educational Resources (OER)

- CrashCourse - Earth Science
- PBS Eons
- Khan Academy - Earth Science
- NOVA PBS - Geology Playlist
- Geology Kitchen
- Rocks and Minerals Education
- MinuteEarth
- TED-Ed - Earth and Space Science
- National Geographic
- The Science Channel

Assessment & Evaluation

Components	Attendance	Quiz/Assignment/	Mid Term	End Term
Weightage (%)	10	20	20	50

Programme and Course Mapping

Course code and title	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO1	PSO2	PSO3	PSO4
UEV101 EARTH AND EARTH SURFACE PROCESSES	**CO 1**	2	2	1	3	1	2	1	1	2	1	2	1	1	1
	CO 2	1	3	1	1	1	2	1	2	2	2	1	3	1	1
	CO 3	2	1	3	2	1	2	1	1	1	1	3	1	2	3
	CO 4	1	1	2	1	2	1	3	1	1	1	1	1	1	2

Unit I	History ofEarth
Local	Understanding local geological history and resources, aiding regional development.
Regional	-
National	-
Global	Engaging in global discussions on Earth's history and geological processes.
Employability	Building foundational knowledge for careers in geology and earth sciences.
Entrepreneurship	Identifying opportunities in geological surveys, resource exploration, and education.
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Considering the geological impact on the environment and resources.
Unit II	Earth system processes
Local	-
Regional	Contributing to regional geological research and hazard assessment.
National	-
Global	-
Employability	-
Entrepreneurship	Building knowledge and skills for careers in seismology, geophysics, and hazard assessment.
Skill Development	Developing expertise in plate tectonics, seismic analysis, and geological hazards.
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Considering the environmental impact of geological processes and hazards.
Unit III	: Minerals and rocks
Local	Understanding local geological formations, aiding local construction and resource management.
Regional	-
National	-
Global	Engaging in global discussions on mineral resources, rock formations, and erosion processes.

Employability	Building foundational knowledge for careers in geology, mining, and resource management.
Entrepreneurship	-
Skill Development	Developing expertise in mineral identification, rock analysis, and geological mapping.
Professional Ethics	Promoting ethical practices in geological resource assessment and mining.
Gender	-
Human Values	-
Environment & Sustainability	Considering the environmental impact of mining and resource extraction.
Unit IV	Earth surface processes
Local	Understanding local coastal and river processes, aiding local environmental management.
Regional	-
National	-
Global	Understanding local coastal and river processes, aiding local environmental management.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in environmental impact assessment and coastal engineering.
Professional Ethics	Promoting ethical practices in environmental research and management.
Gender	-
Human Values	-
Environment & Sustainability	Addressing environmental challenges and climate impacts.
Unit V	Importanceof being a mountain
Local	Understanding local mountain systems and their impact on local climate and culture.
Regional	Contributing to regional studies on mountain systems, climate, and historical developments.
National	Providing insights into the importance of mountains and monsoons in the Indian subcontinent.
Global	Engaging in global discussions on mountain ecosystems, climate, and human history.
Employability	Building knowledge and skills for careers in climate science, geography, and cultural studies.
Entrepreneurship	-
Skill	Developing expertise in climate modeling, cultural heritage

Development	preservation, and geography
Professional Ethics	-
Gender	-
Human Values	Upholding values of cultural preservation, climate understanding, and regional identity.
Environment & Sustainability	Addressing climate impacts and cultural heritage conservation.
SDG	Skill for Decent Work; Sustainable Development and Global Citizenship
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Global Education Knowledge, imagination/creativity, assumption of responsibility and for making decisions, planning, coordinating and organising ability

Teaching Plan:

Weekly teaching Plan	Topic or Unit No.	Textbook/Reference Book/ Open Education Resources (OER)	Teaching-Learning Method
Week 1	Unit 1: History of Earth	Textbook: Earth Science by Author Name and Geologic Time Scale	Lectures, Discussions
Week 2	Unit 1: History of Earth	Textbook: Earth Science and Formation of Earth	Guest Lecture, Visual Aids
Week 3	Unit 2: Earth System Processes	Textbook: Earth Science and Plate Tectonics Interactive	Interactive Sessions, Group Activities
Week 4	Unit 2: Earth System Processes	Textbook: Earth Science and Earthquakes and Volcanoes	Case Studies, Videos
Week 5	Unit 3: Minerals and Rocks	Textbook: Earth Science and Virtual Rock Lab	Lab Practicals, Hands-on Activities
Week 6	Unit 3: Minerals and Rocks	Textbook: Earth Science and Rocks and Minerals	Field Trip, Specimen Analysis
Week 7	Unit 3: Minerals and Rocks	Textbook: Earth Science and Weathering and Erosion	Outdoor Observations, Demonstrations
Week 8	Unit 4: Earth Surface Processes	Textbook: Earth Science and Glaciers and	Simulation, Group

		Glaciation	Projects
Week 9	Unit 4: Earth Surface Processes	Textbook: Earth Science and Coastal Processes	Workshop, Guest Lecture
Week 10	Unit 4: Earth Surface Processes	Textbook: Earth Science and Desert Landforms	Student Presentations, Discussions
Week 11	Unit 5: Importance of Being a Mountain	Textbook: Earth Science and Formation of Himalayas	Debate, Critical Analysis
Week 12	Unit 5: Importance of Being a Mountain	Textbook: Earth Science and Geological Impact on Civilization	Case Study Analysis, Research
Week 13	Unit 5: Importance of Being a Mountain	Textbook: Earth Science and Monsoon Dynamics	Field Trip, Data Collection
Week 14	Review and Assessment	-	Review Sessions, Final Exam

Facilitating the Achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching Learning Activities**	**Assessment Task Methods**
Unit 1	CO1: Enhance understanding of Earth's history, formation, and composition.	Lectures, discussions on solar system formation, Earth's composition, and geological time scale.	Quiz on Earth's history and composition.
Unit 2	CO3: Apply knowledge of minerals, rocks, and geological processes.	Hands-on lab exercises on mineral identification, rock cycle, and weathering.	Lab report assessing mineral and rock identification skills.
Unit 3	CO1: Enhance understanding of Earth's history, formation, and composition.	Guest lectures on specific geological eras and major changes in Earth's history.	Presentation on a chosen geological era.

Unit 4	CO3: Apply knowledge of minerals, rocks, and geological processes.	Workshop on rock structure, igneous, sedimentary, and metamorphic rocks.	Rock identification practical exam.
Unit 5	CO1: Enhance understanding of Earth's history, formation, and composition.	Guest lecture on the formation of Peninsular Indian mountain systems.	Presentation on the geological history of a specific mountain range.

UEV102	**Hydrology and Hydrogeology**	L	T	P	C
Version 1.0		4	0	0	4
Total Contact Hours	**60**				
Pre-requisites/Exposure	Basics of Chemistry				
Co-requisites	--				

Course Description

This course covers the scientific study of water in the environment, including its distribution, movement, and quality. Topics include precipitation, evapotranspiration, infiltration, runoff, groundwater flow, water quality, and water resources management. The course also covers the principles and methods of hydrogeology, including aquifer properties, well hydraulics, and groundwater contamination.

Course Outcomes

CO1 Understand the hydrologic cycle and factors that influence the movement of water in the environment

CO2 Calculate water balances and interpret hydrologic data

CO3 Understand the principles and methods of hydrogeology

CO4 Calculate well yields and interpret pumping test data

CO5 Understand the principles of groundwater contamination and remediation

CO6 Apply hydrologic and hydrogeologic principles to real-world problems and case studies

COURSE CONTENT

Unit 1: Fundamentals of Hydrology and Hydrogeology(15 lectures)
- Introduction to Hydrology and Hydrogeology
- Basic concepts and definitions in hydrology and hydrogeology
- The hydrological cycle and its components
- Precipitation and evapotranspiration processes
- Infiltration and soil water storage
- Surface water hydrology: runoff generation and streamflow analysis
- Groundwater hydrology: aquifers, groundwater flow, and well hydraulics

Unit 2: Hydrological Data Collection and Analysis(15lectures)
- Collection and analysis of hydrological data
- Measurement and analysis of precipitation
- Soil moisture measurement techniques
- Streamflow measurement and hydrograph analysis
- Groundwater level measurement and well hydraulics
- Statistical methods for data analysis in hydrology
- Introduction to hydrological modeling techniques

Unit 3: Water Resources and Management(15lectures)
- Water resources planning and allocation
- Integrated water resources management principles
- Water conservation and demand management
- Water quality parameters and standards
- Groundwater pollution and remediation techniques
- Water quality monitoring and assessment
- Introduction to Geographic Information Systems (GIS) in hydrology

Unit 4: Advanced Topics in Hydrology and Hydrogeology (15lectures)
- Hydrological modeling: model calibration, validation, and applications
- Climate change impacts on hydrological processes
- Flood frequency analysis and floodplain management
- Groundwater exploration techniques
- Spatial analysis and modeling of hydrological data using GIS
- Water policy, governance, and legal frameworks
- Case studies and applications in hydrology and hydrogeology

Suggested Text Books

1. K Subramanya, Engineering Hydrology, Mc-Graw Hill. New Delhi.
2. K N Muthreja, Applied Hydrology, Tata Mc-Graw Hill.
3. K Subramanya, Water Resources Engineering through Objective Questions, Tata McGraw Hill.
4. G L Asawa, Irrigation Engineering, Wiley Eastern

Reference Books/Materials

1. L W Mays, Water Resources Engineering, Wiley.
2. J D Zimmerman, Irrigation, John Wiley & Sons

3. C S P Ojha, R Berndtsson and P Bhunya, Engineering Hydrology, Oxford.
4. R.K. Sharma and T.K. Sharma, Hydrology and Water Resources Engineering, Prentice Hall of India, New Delhi.

Open Educational Resources (OER)

- https://www.usgs.gov/special-topic/water-science-school
- https://www.coursera.org/learn/hydrology-hydrogeology
- https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-72-groundwater-hydrology-spring-2003/
- https://www.epa.gov/water-research/hydrology-research
- http://hydrogeo.uky.edu/
- https://www.bgs.ac.uk/research/groundwater/hydrology.html
- https://ocw.un-ihe.org/courses
- https://oer2go.org/mods/en-boundless/www.boundless.com/environmental-science/textbooks/boundless-environmental-science-textbook/water-resources-5/hydrology-and-water-resources-50/hydrology-245-10941/index.html
- https://hydrology.berkeley.edu/ce-170.html
- https://www.indiawaterportal.org/articles/groundwater-and-hydrogeology-introduction

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Attendance	Quiz/Assignment/	Mid Term	End Term
Weightage (%)	10	20	20	50

Programme and Course Mapping

Course Code and Title	Course Outcomes (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
UEV102 HYDROLOGY	CO1	3	2	1	3	2	3	2	3	2	1	2	2	2	1
	CO2	2	3	1	3	2	3	2	3	1	2	3	2	2	2

AND HYDROGE OLOGY	**CO3**	2	2	2	3	1	3	1	3	1	2	3	1	1	2
	CO4	3	2	3	3	1	3	2	2	1	2	3	2	2	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	**Fundamentals of Hydrology and Hydrogeology**
Local	Understanding local water resources and hydrological processes, aiding local water management.
Regional	-
National	Providing foundational knowledge for national water resource planning and management.
Global	-
Employability	-
Entrepreneurship	Identifying opportunities in water resource consulting, hydrological modeling, and environmental assessments.
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Addressing environmental challenges related to water resources..
Unit II	Hydrological Data Collection and Analysis
Local	-
Regional	-
National	Providing essential data collection and analysis skills for national water resource assessments.
Global	Engaging in global data collection and analysis efforts for understanding hydrological processes.
Employability	-
Entrepreneurship	Student centric methods, such as experiential learning, participative learningand problem-solving methodologies (2.3.1)
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-

Human Values	-
Environment & Sustainability	Applying data analysis to address environmental challenges related to water resources.
Unit III	**Water Resources and Management**
Local	-
Regional	-
National	-
Global	Engaging in global discussions on integrated water resource management and water quality standards.
Employability	Preparing for careers in water resource planning, conservation, water quality management, and GIS.
Entrepreneurship	-
Skill Development	Developing expertise in water resource planning, conservation, and GIS applications.
Professional Ethics	Promoting ethical practices in water resource planning, conservation, and water quality management.
Gender	-
Human Values	-
Environment & Sustainability	Addressing environmental challenges related to water resources and quality.
Unit IV	Advanced Topics in Hydrology and Hydrogeology
Local	Applying advanced hydrological modeling to local flood analysis and climate change impact assessments.
Regional	-
National	-
Global	Engaging in global discussions on climate change impacts, flood analysis, and water policy frameworks.
Employability	Building expertise in hydrological modeling, climate impact assessment, and policy analysis.
Entrepreneurship	-
Skill Development	Enhancing skills in advanced hydrological modeling, GIS-based spatial analysis, and policy analysis.
Professional Ethics	Promoting ethical practices in hydrological modeling, climate impact assessments, and policy analysis.
Gender	-
Human Values	-
Environment & Sustainability	Addressing climate change impacts, flood resilience, and policy development.
SDG	Skill for Decent Work; Sustainable Development and Global Citizenship
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Global Education Knowledge, imagination/creativity, assumption of

	responsibility and for making decisions, planning, coordinating and organising ability

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]- Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Methods
Week 1	Introduction to Hydrology and Hydrogeology	K Subramanya L W Mays USGS Water Science School – Hydrology	Lecture, Discussion
Week 2	Basic Concepts and Definitions	K N Muthreja J D Zimmerman Coursera - Hydrology and Hydrogeology Online Course	Lecture, Case Studies
Week 3	The Hydrological Cycle and Components	K Subramanya C S P Ojha et al. MIT OpenCourseWare – Hydrology	Lecture, Visual Aids
Week 4	Precipitation and Evapotranspiration	G L Asawa R.K. Sharma and T.K. Sharma U.S. EPA - Hydrology Educational Resources	Lecture, Practical Exercise
Week 5	Infiltration and Soil Water Storage	K Subramanya L W Mays Hydrogeology Virtual Laboratory - University of Kentucky	Lecture, Field Visit
Week 6	Surface Water Hydrology	K N Muthreja J D Zimmerman British Geological Survey - Hydrology and Hydrogeology Resources	Lecture, Group Work
Week 7	Groundwater Hydrology	G L Asawa C S P Ojha et al. UNESCO-IHE Hydrology OpenCourseWare	Lecture, Case Studies

Week 8	Hydrological Data Collection and Analysis	K Subramanya R.K. Sharma and T.K. Sharma OpenCourseWare - Hydrology and Water	Lecture, Practical Exercise
Week 9	Measurement and Analysis of Precipitation	K N Muthreja L W Mays India Water Portal - Groundwater and Hydrogeology	Lecture, Field Work
Week 10	Soil Moisture Measurement Techniques	G L Asawa J D Zimmerman Water Resources Engineering - Wiley	Lecture, Practical Exercise
Week 11	Streamflow Measurement and Hydrograph	K Subramanya C S P Ojha et al. Boundless Environmental Science - Hydrology and Water Resources	Lecture, Field Visit
Week 12	Groundwater Level Measurement	K N Muthreja R.K. Sharma and T.K. Sharma University of California, Berkeley - Hydrology and	Lecture, Practical Exercise
Week 13	Statistical Methods for Data Analysis	G L Asawa L W Mays -	Lecture, Group Work
Week 14	Introduction to Hydrological Modeling	K Subramanya J D Zimmerman -	Lecture, Discussion

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching-Learning Activities	Assessment Task Methods

1	• Understand the basic concepts and definitions in hydrology and hydrogeology. • Describe the components of the hydrological cycle and their	• Lecture, Visual Aids, Discussions • Field Visit, Case Studies • Practical Exercises, Data	• Written Test, Quizzes • Field Report, Group Presentations • Data Analysis Assignments • Laboratory
2	• Demonstrate proficiency in collecting and analyzing hydrological data. • Apply statistical methods for data analysis in hydrology. • Understand the	• Field Work, Practical Exercises • Statistical Analysis Workshops • Computer Simulations	• Data Collection, Lab Reports • Data Analysis Assignments, Tests • Model Building Projects
3	• Understand the principles of water resources planning and allocation. • Apply integrated water resources management principles. • Evaluate water	• Lecture, Discussions • Role-plays, Group Discussions • Guest Lectures, Field Visits	• Written Test, Class Participation • Role-play Assessments, Group Reports • Field Report, Guest Lecture
4	• Master hydrological modeling techniques, calibration, validation, and applications. • Understand the impact of climate change on hydrological processes.	• Computer Modeling Exercises, Seminars • Research Readings, Guest Lectures	• Model Application Projects, Seminar Presentation • Research Paper Review, Guest Lecture Reflections • Field Report

UEV103	**NATURAL RESOURCES MANAGEMENT AND SUSTAINABILITY**	**4**	**0**	**0**	**4**
Version 3.0					
Total Contact	**60**				
Pre-	Environmental studies				
Co-requisites	--				

COURSE OBJECTIVES

The course will enable the student-teacher to:

- Understand natural resource classifications, availability factors, and their ecological, social, and economic dimensions.
- Explore strategies for sustainable forestry, water and soil conservation, and techniques to enhance world food production.
- Analyze mineral identification, mining methods, global consumption patterns, and the environmental effects of extraction.
- Evaluate non-renewable resource extraction, its environmental impact, and the potential of renewable sources for sustainable energy solutions.
- Examine various approaches, integrated strategies, and principles of sustainability science for effective resource management.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Understand resource classifications, degradation factors, and human impact on natural resources.

CO2: Apply resource management strategies to forestry, water, soil, and food resources.

CO3: Evaluate environmental impacts of mineral extraction and analyze non-renewable energy sources.

CO4: Develop integrated resource management plans and propose solutions for sustainable energy and resource utilization.

CATALOG DESCRIPTION

This course explore the classification, availability, and conservation of resources, both renewable and non-renewable. Investigate mineral resources, their identification, extraction methods, and the global consumption patterns that shape our world. Gain insights into energy resources, from oil and gas to renewable sources like solar, wind, and nuclear power, assessing their environmental impacts and potential. Understand resource management approaches, integrated strategies, and sustainability science principles to address real-world challenges. Through a balanced mix of theory, case studies, and discussions, develop a holistic understanding of how our actions impact the planet and how responsible resource management can shape a sustainable future.

Unit1:Introduction **(10lectures)**

Resource and reserves; classification of natural resources; renewable and non-renewable resources;resourcedegradation;resourceconservation;resourceavailabilityandfactorsinfluenc ngitsavailability; land resources; water resources; fisheries and other marine resources; energy resources;mineral resources; human impact on natural resources; ecological, social and economic dimension ofresourcemanagement.

Unit2:Naturalresourcesandconservation **(10lectures)**

Forestresources:economicandecologicalimportanceofforests,forestmanagementstrategies,sustainablef orestry;waterresources:supply,renewal,anduseofwaterresources,freshwatershortages,strategiesofwater conservation;soilresources:importanceofsoil,soilconservationstrategies; food resources: world food problem, techniques to increase world food production, greenrevolution.

Unit3:Mineralresources **(10lectures)**

Mineral resources and the rock cycle; identified resources; undiscovered resources; reserves; types ofmining: surface, subsurface, open-pit, dredging, strip; reserve-to-production ratio; global consumptionpatterns of mineral resources techniques to increase mineral resource supplies; ocean mining formineralresources;environmentaleffectsofextractingandusingmineralresources.

Unit4:Non-renewableenergyresources **(10lectures)**

Oil: formation, exploration, extraction and processing, oil shale, tar sands; natural gas: exploration,liquefied petroleum gas, liquefied natural gas; coal: reserves, classification, formation, extraction,processing, coal gasification; environmental impacts of nonrenewable energy consumption; impact ofenergy consumption on global economy; application of green technology; future energy options andchallenges.

Unit5:Renewableenergyresources **(10lectures)**

Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive andactivesolarheatingsystem,solarthermalsystems,solarcells,JNNsolarmission;hydropower:technolog y, potential, operational costs, benefits of hydropower development; nuclear power: nuclearfission, fusion, reactors, pros and cons of nuclear power, storage of radioactive waste, radioactivecontamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermalenergy;energy frombiomass; bio-diesel.

Unit6:Resourcemanagement **(10lectures)**

Approachesinresourcemanagement:ecologicalapproach;economicapproach;ethnologicalapproach;implicationsoftheapproaches;integratedresourcemanagementstrategies;conceptofsustainabilityscience:differentapproachtowardssustainabledevelopmentanditsdifferentconstituents; sustainability of society, resources and framework; sustainable energy strategy; principlesofenergy conservation;Indian renewableenergy programme.

Suggested Text Books

1. Craig,J.R.,Vaughan.D.J.&Skinner.B.J.1996.*ResourcesoftheEarth:Origin,Use,andEnvironmentalImpacts* (2nd edition).PrenticeHall, New Jersey.
2. Freeman, A.M. 2001. *Measures of value and Resources: Resources for the Future*. WashingtonDC.
3. Freeman,A.M.2003.*MillenniumEcosystemAssessment:ConceptualFramework*.IslandPress.
4. Ginley,D.S.&Cahen,D.2011.*FundamentalsofMaterialsforEnergyandEnvironmentalSustainability*.CambridgeUniversity Press.
5. Klee,G.A.1991.*ConservationofNaturalResources*.PrenticeHallPublication.
6. Miller,T.G.2012.*EnvironmentalScience*.WadsworthPublishingCo.
7. Owen,O.S,Chiras,D.D,&Reganold,J.P.1998.*NaturalResourceConservation–Managementfor Sustainable Future* (7thedition). PrenticeHall.
8. Ramade,F.1984.*EcologyofNaturalResources*.JohnWiley&SonsLtd.
9. Tiwari,G.N.&Ghosal.M.K.2005.*RenewableEnergyResources:BasicPrinciplesandApplication*.NarosaPublishing House.

Open Educational Resources (OER)

https://www.k-state.edu/nrm/webinars/intro/index.html)
https://open.oregonstate.education/woodproducts/)
https://www.sc.edu/study/colleges_schools/artsandsciences/environment_and_sustainability/academics/courses/introduction_to_geology.php
https://www.energy.gov/eere/education/energy-education-resources
https://www.umass.edu/windenergy/education/renewable-energy-and-environmental-sustainability
https://ocw.uci.edu/collections/7ba20ee3-0e56-46a5-b6c2-334eb7cb8c10

Assessment & Evaluation

Components	Assignment	Mid Term Examination	Attendance	End Term Examination
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course Code and Title	Course Outcomes (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
UEV103 Natural Resources mangementand sustainability	CO1	3	2	1	3	2	3	2	3	2	1	2	2	2	1
	CO2	2	3	1	3	2	3	2	3	1	2	3	2	2	2
	CO3	2	2	2	3	1	3	1	3	1	2	3	1	1	2
	CO4	3	2	3	3	1	3	2	2	1	2	3	2	2	3

Unit I	Natural Resources and Conservation
Local	Understanding local natural resources and their classification, importance, and conservation.
Regional	-
National	-
Global	Engaging in global discussions on sustainable forestry, water conservation, and food security.
Employability	Preparing for careers in resource conservation, sustainable agriculture, and environmental consulting
Entrepreneurship	Student centric methods, such as experiential learning, participative learning and problem-solving methodologies (2.3.1)
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Disciplinary knowledge; Research related skills; scientific skills,
Gender	-
Human Values	-
Environment & Sustainability	Concepts of environment which enable student to solve basic problems related to their surroundings.
Unit II	Mineral Resources
Local	Understanding local mineral resources, mining techniques, and environmental impacts.
Regional	-

National	-
Global	Engaging in global discussions on mineral resource availability, extraction, and environmental impact mitigation
Employability	-
Entrepreneurship	Developing expertise in mineral resource assessment, extraction, and environmental impact assessment.
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem
Professional Ethics	Promoting ethical practices in mineral resource exploration and mining.
Gender	-
Human Values	-
Environment & Sustainability	Addressing environmental challenges related to mineral resource extraction.
Unit III	Non-renewable Energy Resources
Local	-
Regional	-
National	-
Global	Engaging in global discussions on energy consumption, environmental impacts, and alternative energy sources.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in energy resource assessment, environmental impact assessment, and energy policy analysis
Professional Ethics	Promoting ethical practices in the energy sector, including responsible extraction and environmental protection.
Gender	-
Human Values	-
Environment & Sustainability	Addressing environmental challenges related to non-renewable energy consumption.
Unit IV	Renewable Energy Resources
Local	-
Regional	-
National	-
Global	Engaging in global discussions on renewable energy adoption, sustainability, and climate change mitigation
Employability	-
Entrepreneurship	-
Skill Development	Entrepreneurship; Team work/ Creativity by designing research problem

Professional Ethics	Promoting ethical practices in renewable energy development and climate change mitigation.
Gender	-
Human Values	-
Environment & Sustainability	Addressing environmental challenges through renewable energy adoption and sustainable practices
Unit V	Resource Management
Local	-
Regional	-
National	Providing knowledge of sustainable resource management for national development.
Global	Engaging in global discussions on sustainable development, resource conservation, and energy strategy.
Employability	Preparing for careers in resource management, sustainability consulting, and energy policy.
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Addressing environmental challenges related to resource management and sustainability.
SDG	Skill for Decent Work; Sustainable Development and Global Citizenship
NEP	Quality Universities and Colleges: A New and Forward-looking Vision for India's ; India's Higher Education System (9.1- 9.3)
POE/4th IR	Global Education Knowledge, imagination/creativity, assumption of responsibility and for making decisions, planning, coordinating and organising ability

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Method
Week 1	Introduction	TB: Keller, E. D. (2012). "Intro to Environmental Geology." Ch. 1	Lecture, Discussion

Week2	Classification of Resources	TB: Keller, E. D. (2012). Ch. 2	Lecture, Group Activities
Week3	Renewable and Non-renewable Res.	TB: Keller, E. D. (2012). Ch. 3	Lecture, Case Studies
Week4	Resource Degradation and Cons.	TB: Keller, E. D. (2012). Ch. 4	Lecture, Interactive Quizzes
Week5	Land and Water Resources	TB: Keller, E. D. (2012). Ch. 5	Lecture, Field Trip (if possible)
Week6	Energy Resources	TB: Keller, E. D. (2012). Ch. 6	Lecture, Guest Speaker (Energy Expert)
Week7	Mineral Resources	RB: Strahler, A. "Intro to Physical Geology." Page 632	Lecture, Case Studies
Week8	Non-renewable Energy Resources	TB: Keller, E. D. (2012). Ch. 7	Lecture, Debates
Week9	Renewable Energy Resources	RB: Monroe, J. S., Wicander, R., &Hazlett, R. Page 690	Lecture, Group Projects
Week10	Resource Management	TB: Keller, E. D. (2012). Ch. 8	Lecture, Case Studies
Week11	Approaches to Resource Management	RB: Hyndman, D., & Hyndman, D. (2011). Page 571	Lecture, Group Discussions
Week12	Sustainability and Energy Cons.	TB: Keller, E. D. (2012). Ch. 9	Lecture, Guest Speaker (Sustainability Expert)
Week13	Indian Renewable Energy Programme	OER: Ministry of New and Renewabl e Energy, Governme nt of India	Lecture, Multimedia Presentation
Week14	Review and Assessment		Revision, Assessment

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
Unit 1	Understand natural resource classifications, availability factors, and their dimensions.	Lecture on resource classifications and factors affecting availability.	Quiz on key concepts and factors influencing resource availability.
Unit 2	Explore strategies for sustainable forestry, water and soil conservation, and food production techniques.	Group discussion on the economic and ecological importance of forests and water resources.	Group presentation on a chosen conservatio n strategy.
Unit 3	Analyze mineral identification, extraction methods, and global consumption patterns.	Case study analysis of mining techniques and their impact on resources.	Written report on the environmental effects of mineral extraction.
Unit 4	Evaluate non-renewable resource extraction and its impact on the global economy.	Debate on the pros and cons of non-renewable energy sources.	Participation in the debate and a follow-up reflective essay.
Unit 5	Understand various renewable energy sources and their potential.	Hands-on activity to build a simple solar cell or wind turbine model.	Presentation on the chosen renewable energy source and its benefits.
Unit 6	Examine different approaches to resource management and sustainability principles.	Case study discussion on successful resource management strategies.	Group project assessing the ecological, economic, and ethical aspects of a resource management approach.

UEV104	**NATURAL AND ANTHROPOGENIC HAZARDS**	**L**	**T**	**P**	**C**
Version 3.0		**4**	**0**	**0**	**4**
Total Contact Hours	**60**				

Pre-requisites/Exposure	Baics of Environment
Co-requisites	--

COURSE OBJECTIVES

The course will enable the student-teacher to:

- Understand natural and anthropogenic hazards and their causes.
- Analyze the impacts of these hazards, using case studies.
- Study prediction and mitigation strategies for minimizing damage.
- Emphasize environmental responsibility and sustainable practices.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Identify various natural and anthropogenic hazards and their distinguishing features.
CO2: Evaluate the consequences of hazards on ecosystems, infrastructure, and communities.
CO3: Apply knowledge of prediction and mitigation techniques to reduce hazard impact.
CO4: Analyze case studies to extract lessons for effective hazard management.
CO5: Propose strategies for sustainable practices and pollution control.
CO6: Demonstrate awareness of environmental responsibility in preventing hazards.

CATALOG DESCRIPTION

This course offers a comprehensive exploration of natural and anthropogenic hazards, delving into their origins, impacts, mitigation strategies, and environmental implications. The curriculum encompasses a broad spectrum of hazards, from geological phenomena like earthquakes and volcanic eruptions to meteorological events such as storms and floods. Additionally, the course addresses anthropogenic hazards, including pollution and waste management. Through a combination of theoretical study and case analysis, students will gain insights into predicting catastrophes, minimizing damage, and fostering sustainable practices. This interdisciplinary course empowers students to comprehend the complex interplay between natural forces, human activities, and environmental responsibility.

COURSE CONTENT

Unit I NATURAL AND ANTHROPOGENIC HAZARDS (15 lectures)

Natural Hazards and Disasters, Human Impact on Natural Disaster, Predicting Catastrophe, Mitigating Hazards; Plate Tectonics and related Hazards, Earthquakes and their causes, Ground Motion and Failures, Case study of Nepal earthquake and Bhuj earthquake; Tsunami: Giant Tsunamis, Generation and Movement, Tsunami Hazard Assessment, Tsunami – 2004, Fukushima disaster

Unit II Volcanic Hazard (15 lectures)

Eruption-Type of Volcanoes and Tectonic environment; Landslide and their causes, Type of downslope movement, associated hazard, Land Subsidence and associated hazard; Floods and Human Interaction, Flood Frequency and Recurrence Interval, Human intervention and mitigation; Storms: Tropical Cyclone, Hurricane, Tornado, Storm damage and safety; Wildfires: Fire Process and Secondary effects; Case studies of devastating natural hazards

Unit III Anthropogenic Disasters I (15lectures)

Pollution: Role of natural and anthropogenic factors; Population growth and Environmental Impact; Carrying capacity of ecosystem; Soil and soil degradation, desertification, Ways to improve soil and case studies related to soil degradation

Unit IV Anthropogenic Disasters II (15 lectures)

Fundamental concepts of water and atmospheric pollution, Air Act, Water Act, Ambient Air quality, case studies related to water and atmospheric pollution; Waste and Hazardous

Suggested Text Books

1. Natural Hazards and Disasters" by D. Hyndman & D. Hyndman:
2. "Introduction to Environmental Geology" by E. A. Keller
3. "Environmental Hazards: Assessing Risk and Reducing Disaster" by K. Smith
4. "Introduction to Environmental Engineering and Science" by G. M. Masters & W. P. Ela
5. "Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes" by E. A. Keller & D. E. DeVecchio
6. "Environmental Science: Earth as a Living Planet" by D. B. Botkin& E. A. Keller

Open Educational Resources (OER)

- https://openstax.org/details/books/earth-science
- https://www.nssl.noaa.gov/education

- https://www.usgs.gov/natural-hazards/earthquake-hazards
- https://volcano.si.edu
- https://www.fema.gov/
- http://www.unesco.org/new/en/education/themes/education-building-blocks/disaster-risk-reduction/resources/
- https://open.umn.edu/opentextbooks/textbooks?subject_area_id=28
- https://www.merlot.org/merlot/materials.htm?category=2665

Assessment & Evaluation

Components	Assignment	Mid Term	Attend	End Term
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course Code and Title	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
UEC 104 NATURAL AND ANTHROPOGENIC HAZARDS	CO1	2	1	2	2	2	2	2	2	1	1	3	3	1	2
	CO2	2	2	2	2	2	3	2	2	1	1	2	2	2	3
	CO3	2	2	1	2	2	2	2	2	1	1	1	2	1	2
	CO4	2	2	2	2	2	3	2	2	2	2	2	2	2	3

Unit I	Natural Hazards and Disasters
Local	-
Regional	-
National	-
Global	Engaging in global discussions on natural hazards, disaster risk reduction.
Employability	-
Entrepreneurship	-

Skill Development	Developing expertise in disaster prediction, mitigation, and response.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Addressing environmental challenges related to disaster impact and recovery.
Unit II	Volcanic Hazard and Other Hazards
Local	-
Regional	-
National	Providing knowledge for national disaster planning and risk assessment.
Global	-
Employability	-
Entrepreneurship	-
Skill Development	eveloping expertise in volcanic hazard assessment, landslides, floods, and storm mitigation
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Addressing environmental challenges related to geological hazards and climate-related disasters.
Unit III	**Anthropogenic Disasters I**
Local	-
Regional	-
National	-
Global	Engaging in global discussions on pollution, carrying capacity, and soil conservation.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in pollution control, soil conservation, and sustainable practices.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Addressing environmental challenges related to pollution and soil degradation.

Unit IV	**Anthropogenic Disasters II**
Local	-
Regional	-
National	Providing knowledge for national pollution control policies, air, and water quality management.
Global	-
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Addressing environmental challenges related to pollution and waste generation.
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	India's Higher Education System (9.1- 9.3), Promoting High Quality research (18.1-18.9); Technology Use and Integration (23.1-23.13)
POE/4th IR	Global Education Knowledge, Technical Skill that match Industry Needs, Focus on Emloyability Skills (Regional/ Global), Internship Program, On Campus Job

Teaching Plan:

Weekly Teaching Plan	**Topic/Unit No.**	**Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]**	**Teaching-Learning Method**
Week 1	Introduction to Natural Hazards and Disasters	"Natural Hazards and Disasters" - D. Hyndman & D. Hyndman, Ch 1	Lecture, Discussion
Week 2	Human Impact on Natural Disaster	"Natural Hazards and Disasters" - Ch 2	Lecture, Case Study

Week 3	Plate Tectonics and related Hazards	"Natural Hazards and Disasters" - Ch 3	Lecture, Visual Aids
Week 4	Earthquakes and their causes	"Natural Hazards and Disasters" - Ch 4	Lecture, Simulation
Week 5	Tsunami: Generation and Movement	"Natural Hazards and Disasters" - Ch 5	Lecture, Videos
Week 6	Case study: Tsunami 2004 and Fukushima disaster	"Natural Hazards and Disasters" - Ch 5	Group Discussion
Week 7	Volcanic Hazard: Eruption-Type of Volcanoes	"Introduction to Environmental Geology" - E. A. Keller, Ch 6	Lecture, Diagrams
Week 8	Landslides and associated hazards	"Introduction to Environmental Geology" - Ch 7	Lecture, Group Activity
Week 9	Floods and Human Interaction	"Introduction to Environmental Geology" - Ch 8	Lecture, Guest Speaker
Week 10	Storms: Tropical Cyclone, Hurricane, Tornado	"Environmental Hazards: Assessing Risk and Reducing Disaster" - K. Smith, Ch 9	Lecture, Discussion
Week 11	Wildfires: Fire Process and Secondary Effects	"Environmental Hazards: Assessing Risk and Reducing Disaster" - Ch 10	Lecture, Case Study
Week 12	Anthropogenic Disasters I: Pollution	"Introduction to Environmental Engineering and Science" - G. M. Masters & W. P. Ela, Ch 11	Lecture, Videos

Week 13	Population growth and Environmental Impact	"Introduction to Environmental Engineering and Science" - Ch 12	Lecture, Group Discussion
Week 14	Anthropogenic Disasters II: Water and Atmospheric Pollution	"Environmental Science: Earth as a Living Planet" - D. B. Botkin& E. A. Keller, Ch 13	Lecture, Case Study

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	In Unit I, students will grasp the complexities of natural hazards and their effects on communities, delve into the human influence on these disasters, explore predictive methods, and analyze approaches to minimize their impact. They will also gain insights into plate tectonics, earthquake causes, and ground motion, and evaluate case studies such as the Nepal and Bhuj earthquakes.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Unit II will build upon this foundation by examining volcanic hazards, landslides, floods, and storm-related phenomena. Students will comprehend different types of downslope movements, explore human intervention in flood scenarios, and assess the aftermath of storms.		
3	In Unit III, the focus shifts to anthropogenic disasters, exploring pollution's natural and human factors, population growth's environmental impact, and the concept of carrying capacity in ecosystems. Moreover, students will study soil degradation, desertification, and strategies to enhance soil quality, alongside analyzing case studies on soil-related challenges.		
4	In the final unit, Unit IV, students will delve into fundamental concepts of water		

	and atmospheric pollution, examine regulatory frameworks, comprehend ambient air quality, and engage with case studies on pollution and waste. By the end of the course, students will have gained a comprehensive understanding of natural and anthropogenic hazards, enabling them to critically evaluate their impact and contribute to sustainable solutions.		

UEV105	**ENVIRONMENT LEGISLATION POLICIES AND ESG'S**	**L**	**T**	**P**	**C**
Version 3.0		**4**	**0**	**0**	**4**
Total Contact	**60**				
Pre-					
Co-requisites	**--**				

COURSE OBJECTIVES

The course will enable the student-teacher to:

- Clarify constitutional aspects of environmental protection and governmental roles.
- Explore the historical roots shaping modern environmental laws and policies.
- Define vital legal terms and understand key constitutional duties.
- Study significant environmental laws and their implications.
- Analyze current environmental challenges through recent legislation and eco-friendly initiatives.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Knowledge: Understand constitutional and governmental aspects of environmental protection.
CO2: Comprehension: Summarize the historical development of environmental laws.
CO3: Application: Apply legal definitions to real-world environmental scenarios.
CO4: Analysis: Analyze provisions and impacts of key environmental laws.
CO5: Synthesis: Compare ancient and modern conservation approaches.
CO6: Evaluation: Assess recent laws' effectiveness in addressing current environmental issues.

CATALOG DESCRIPTION

This course provides a comprehensive exploration of environmental legislation, policies, and Environmental, Social, and Governance (ESG) principles. Through in-depth theoretical study, students will understand the constitutional foundation of environmental protection, the historical evolution of environmental laws, and the significance of legal definitions related to pollution, biodiversity, and sustainable development. The course delves into key legislative instruments such as the Indian Forest Act, Wildlife Protection Act, and Environmental Protection Act, enabling students to analyze their provisions and implications. By evaluating recent laws like the Biological Diversity Act and National Green Tribunal Act, students will assess their effectiveness in addressing contemporary environmental challenges. This course equips students with essential knowledge to navigate complex environmental legal frameworks and contribute meaningfully to sustainable practices and policies

COURSE CONTENT

Unit1: Introduction (10lectures)

Constitution of India; fundamental rights; fundamental duties; Union of India; union list, state list,concurrent list; legislature; state assemblies; judiciary; panchayats and municipal bodies; NationalGreenTribunal.

Unit2:Historyofenvironmental legislation and policy (20lectures)

Ancientperiod:worshipofwater,air,trees;Mauryanperiod:Kautilya'sArthashastra,Yajnavalkyasmritiandandharaksamhita;Medievalperiod:forestsaswoodlandandhuntingresourcesduring Mughal reign; British India: Indian Penal Code 1860,Forest Act 1865, Fisheries Act1897;Independent India: Van Mahotsava 1950, National Forest Policy 1952, Orissa River pollutionandprevention Act 1953.

Unit3:Environmental legislation(10lectures)

Legaldefinitions(environmentalpollution,naturalresource,biodiversity,forest,sustainabledevelopment);Article 48A (The protection and improvement of environment and safeguarding offorestsand wildlife);Article51 A (Fundamentalduties).

Unit4:Legislative Instruments(20lectures)

TheIndianForestAct1927;TheWildlife(Protection)Act1972;TheWater(PreventionandControlofPollution) Act 1974; The Forests (Conservation) Act 1980; The Air (Prevention and Control ofPollution) Act 1981; The Environment (Protection) Act 1986; Motor Vehicle Act 1988; The PublicLiability Insurance Act 1991; Noise Pollution (Regulation and Control) Rules 2000; The BiologicalDiversity Act 2002; The Schedule Tribes and other Traditional Dwellers (Recognition of ForestsRights)Act2006;TheNationalGreenTribunalAct2010;schemeandlabelingofenvironmentfriendlyproducts, Ecomarks.

Suggested Text Books

1. "Environmental Law in India" by ShyamDiwan and Armin Rosencranz
2. "Environmental Law" by Bimal N. Patel
3. "Environmental Management: Text and Cases" by Rajagopalan Raman
4. "Environmental Laws in India: An Introduction" by Gurdip Singh
5. "Environmental Legislation and Policy: Selected Statutes" by Gitanjali Nain Gill

6. "Environmental Governance in India: Problems and Perspectives" by N.C. Saxena and KanchiKohli
7. "Environmental Law: Pollution and Management" by Suresh P. Harsha and PallaviBedi

Open Educational Resources (OER)

- https://openstax.org/details/books/earth-science
- https://www.nssl.noaa.gov/education
- https://www.usgs.gov/natural-hazards/earthquake-hazards
- https://volcano.si.edu
- https://www.fema.gov/
- http://www.unesco.org/new/en/education/themes/education-building-blocks/disaster-risk-reduction/resources/
- https://open.umn.edu/opentextbooks/textbooks?subject_area_id=28
- https://www.merlot.org/merlot/materials.htm?category=2665

Assessment & Evaluation

Components	Attendance	Quiz/Assignment/	Mid Term	End Term
Weightage (%)	10	20	20	50

Programme and Course Mapping

Course Code and Title	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
UEV105 ENVIRONMENT LEGISLATION POLICIES AND ESG'S	CO1	2	1	1	1	2	1	1	3	2	1	2	1	1	1
	CO2	1	1	1	2	1	1	1	1	1	1	1	1	1	1
	CO3	1	1	1	1	2	1	1	1	1	1	1	1	1	1
	CO4	1	2	1	3	2	2	1	1	2	2	1	1	1	3
	CO5	2	1	1	2	1	2	1	2	1	2	2	1	1	2

	CO6	**1**	**2**	**1**	**3**	**2**	**2**	**1**	**3**	**2**	**3**	**1**	**2**	**1**	**2**

Unit I	**Introduction**
Local	Understanding local governance, panchayats, and municipal bodies in the context of environmental regulation.
Regional	-
National	-
Global	-
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in environmental law, policy analysis, and advocacy.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	**History of Environmental Legislation**
Local	-
Regional	-
National	Understanding the evolution of environmental legislation and policy in the country
Global	-
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in environmental law, policy analysis, and historical research.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	**Environmental Legislation**
Local	-
Regional	-
National	-

Global	Recognizing the importance of international legal principles in environmental protection.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in environmental law and regulatory compliance.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit IV	**Legislative Instruments**
Local	-
Regional	-
National	-
Global	Recognizing the global relevance of legislative instruments in environmental governance.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment &Sustainability	-
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	India's Higher Education System (9.1- 9.3), Promoting High Quality research (18.1-18.9); Technology Use and Integration (23.1-23.13)
POE/4th IR	Global Education Knowledge, Technical Skill that match Industry Needs, Focus on Emloyability Skills (Regional/ Global), Internship Program, On Campus Job

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Method
1	Introduction	"Environmental Law in India" by ShyamDiwan and Armin Rosencranz	Lecture, Discussion, Introduction to Constitutional Framework
2-3	History of Environmental Laws	"Environmental Law" by Bimal N. Patel	Lecture, Reading Analysis, Historical Perspectives
4-5	Environmental Legislation	"Environmental Law" by Bimal N. Patel	Lecture, Case Studies, Legal Definitions
6-8	Legislative Instruments	"Environmental Law" by Bimal N. Patel	Lecture, Case Studies, Analysis of Key Environmental Laws
9-10	ESG Principles	OER: ESG Fundamentals	Lecture, Discussion, ESG Application in Environmental Context
11-12	National Green Tribunal	TB: Unit 1	Lecture, Case Studies, Role and Impact of NGT
13	Review and Discussion	TB: All Units	Group Discussion, Q&A Sessions, Course Review

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	In the "Introduction" unit, students will familiarize themselves with the environmental dimensions of the Indian Constitution and gain insights into the roles played by various governmental entities in ensuring environmental protection. Moreover, they will grasp the significance of the National Green Tribunal as a key institution in the realm of environmental governance	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii)	• Presentations and class discussions. • Assignments and class tests. • Student presentations.

2	Moving on to the "History of Environmental Legislation and Policy" unit, students will trace the historical trajectory of environmental laws, allowing them to comprehend the evolution from ancient practices to modern regulations. By evaluating environmental perspectives throughout distinct historical periods, students will appreciate the diverse influences that have shaped current policies.	Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
3	Transitioning to the "Environmental Legislation" unit, learners will acquire a firm grasp of pivotal legal terminologies linked to environmental contexts. Additionally, they will interpret and appreciate the relevance of specific articles within the Constitution, illuminating their role in fostering environmental preservation and sustainability.		
4	Finally, in the "Legislative Instruments" unit, students will engage in a comprehensive analysis of significant environmental laws. Through this process, they will develop an understanding of the provisions and far-reaching impacts of these laws on environmental preservation. By evaluating the effectiveness of these legislative measures in addressing contemporary ecological challenges, students will gain a nuanced perspective on the broader legal framework governing environmental protection.		

UEV106	**Waste Management**	**L**	**T**	**P**	**C**
Version 3.0		**0**	**0**	**0**	**4**
Total Contact Hours	**60**				
Pre-requisites/Exposure	Basics ofEnvironment				
Co-requisites	--				

COURSE OBJECTIVES

The course will enable the student-teacher to:

1. Understand the composition and sources of solid waste, including hazardous and biomedical waste.
2. Analyze the environmental impact of solid waste disposal on human health, water, soil, and ecosystems.
3. Explore techniques for solid waste collection, disposal, and resource recovery, including waste-to-energy processes.
4. Study waste management policies, integrated approaches, and the concept of lifecycle assessment (LCA).
5. Gain insights into eco-friendly products, promoting sustainable waste management practices.

COURSE OUTCOMES (CO)

On completion of this course, the student-teacher will be able to:

CO1: Identify various sources of solid waste and differentiate their classifications and chemical compositions.

CO2: Assess the impact of solid waste disposal on the environment, human health, water quality, and ecosystems.

CO3: Apply knowledge of solid waste management techniques, including collection, transportation, and disposal.

CO4: Analyze resource recovery methods such as composting, anaerobic digestion, and waste-to-energy processes.

CO5: Evaluate waste management policies, integrated approaches, and the role of lifecycle assessment (LCA) in sustainability.

CO6: Recognize the significance of eco-friendly products and their role in promoting sustainable waste management practices.

CATALOG DESCRIPTION

The "Waste Management" course provides a comprehensive exploration of the sources, impact, management, and sustainable solutions related to solid waste. Through a structured curriculum, students will delve into the characterization of various types of solid waste, their effects on the environment, and methods of collection, disposal, and resource recovery. The course encompasses vital topics such as hazardous waste, industrial waste, and the integration of waste management practices. Students will also gain insight into eco-friendly products and their alignment with sustainable waste management policies. By the course's conclusion, students will possess a holistic understanding of waste management's significance and its crucial role in environmental sustainability.

COURSE CONTENT

Unit1:Introduction(5lectures)

Sources and generation of solid waste, their classification and chemical composition; characterizationofmunicipal solid waste;hazardouswasteandbiomedicalwaste.

Unit2:Effectofsolidwastedisposalonenvironment(8lectures)

Impact of solid waste on environment, human and plant health; effect of solid waste and industrialeffluent discharge on water quality and aquatic life; mining waste and land degradation; effect of landfill eachateon soil characteristicsand ground water pollution.

Unit3:SolidwasteManagement(9lectures)

Different techniques used in collection, storage, transportation and disposal of solid waste (municipal,hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal
treatment(pyrolysisandincineration)ofwastematerial;drawbacksinwastemanagementtechniques.

Unit4: Industrialwastemanagement(8lectures)

Types of industrial waste: hazardous and non-hazardous; effect of industrial waste on air, water andsoil; industrial waste management and its importance; stack emission control and emission monitoring;effluenttreatmentplantandsewagetreatmentplant.

Unit5:ResourceRecovery(6lectures)

4R-reduce,reuse,recycleandrecover;biologicalprocessing-composting,anaerobicdigestion,aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques forwastetreatment.

Unit6: Waste- to-energy(WTE) (6lectures)

Conceptofenergyrecoveryfromwaste;refusederivedfuel(RDF);differentWTEprocesses:combustion,pyrolysis, landfillgas (LFG)recovery;anaerobicdigestion;gasification.

Unit7:Integratedwastemanagement(6lectures)

Concept of Integrated waste management; waste management hierarchy; methods and importance ofIntegratedwastemanagement.

Unit8:Lifecycleassessment(LCA)(6lectures)

Cradle to grave approach; lifecycle inventory of solid waste; role of LCA in waste management;advantageand limitation of LCA; casestudyonLCA of aproduct.

Unit9:Policiesforsolidwastemanagement(6lectures)

Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management andHandling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Ecofriendly orgreenproducts.

Suggested Text Books

1. "Solid Waste Management: Engineering Principles and Management Issues" by Tchobanoglous et al.
2. "Introduction to Solid Waste Management" by Tebbutt.
3. "Waste Management Practices: Municipal, Hazardous, and Industrial" by Pichtel.
4. "Handbook of Solid Waste Management" by Kreith and Tchobanoglous.
5. "Waste Management and Sustainable Consumption" by Cooper.
6. "Hazardous Waste Management" by LaGrega et al.
7. "Biomedical Waste Management: Principles and Case Study" by Bhandari.

Open Educational Resources (OER)

- https://openstax.org/details/books/earth-science
- https://www.nssl.noaa.gov/education
- https://www.usgs.gov/natural-hazards/earthquake-hazards
- https://volcano.si.edu
- https://www.fema.gov/
- http://www.unesco.org/new/en/education/themes/education-building-blocks/disaster-risk-reduction/resources/
- https://open.umn.edu/opentextbooks/textbooks?subject_area_id=28
- https://www.merlot.org/merlot/materials.htm?category=2665

Assessment & Evaluation

Components	Attendance	Quiz/Assignment/	Mid Term	End Term
Weightage (%)	10	20	20	50

Programme and Course Mapping

Course Code and Title	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
UEV 106 WASTE	CO1	3	1	2	2	2	3	1	2	1	1	3	2	1	3

MANAGE MENT	**CO2**	**3**	**2**	**2**	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**3**
	CO3	**1**	**1**	**1**	**2**	**1**	**3**	**2**	**2**	**1**	**1**	**1**	**3**	**1**	**3**
	CO4	**1**	**1**	**2**	**3**	**1**	**3**	**1**	**2**	**1**	**1**	**1**	**2**	**1**	**3**
	CO5	**2**	**2**	**1**	**3**	**3**	**2**	**3**	**2**	**1**	**2**	**1**	**2**	**2**	**3**
	CO6	**1**	**1**	**1**	**1**	**3**	**3**	**3**	**2**	**1**	**3**	**1**	**1**	**1**	**2**

Unit I	**Introduction**
Local	Understanding local sources and generation of solid waste, municipal waste classification, and local waste characterization.
Regional	-
National	-
Global	-
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in waste characterization and management techniques
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	**Effect of Solid Waste Disposal on Environment**
Local	-
Regional	-
National	Recognizing the national implications of improper solid waste disposal on water quality and land degradation.
Global	-
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in assessing and mitigating the environmental impact of waste disposal.
Professional Ethics	-
Gender	-
Human Values	-

Environment & Sustainability	-
Unit III	**Solid Waste Management**
Local	-
Regional	-
National	-
Global	Recognizing global best practices in solid waste management.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Promoting sustainable waste management practices and reducing environmental impact.
Unit IV	**Industrial Waste Management**
Local	-
Regional	-
National	-
Global	Comprehending national regulations for industrial waste management and stack emission control.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in industrial waste management and pollution control technologies.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit V	**Resource Recovery**
Local	-
Regional	-
National	Recognizing national initiatives for resource recovery and waste reduction.
Global	Recognizing the global relevance of legislative instruments in environmental governance.
Employability	-
Entrepreneurship	-
Skill Development	-

Professional Ethics	-
Gender	-
Human Values	-
Environment &Sustainability	-
Unit VI	**Waste-to-Energy (WTE)**
Local	-
Regional	-
National	-
Global	Recognizing global trends in waste-to-energy technologies.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment &Sustainability	Promoting energy recovery from waste as a sustainable practice.
Unit VII	**Integrated Waste Management**
Local	-
Regional	-
National	-
Global	Understanding the global significance of integrated waste management.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment &Sustainability	Applying lifecycle assessment to reduce environmental impact and promote sustainable waste management.
Unit VIII	**Policies for Solid Waste Management**
Local	-
Regional	-
National	Comprehending national policies and rules governing solid waste management.
Global	-
Employability	-
Entrepreneurship	-

Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment &Sustainability	Promoting policies that support sustainable waste management practices.
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	India's Higher Education System (9.1- 9.3), Promoting High Quality research (18.1-18.9); Technology Use and Integration (23.1-23.13)
POE/4th IR	Global Education Knowledge, Technical Skill that match Industry Needs, Focus on Emloyability Skills (Regional/ Global), Internship Program, On Campus Job

Teaching Plan:

Weekly Teaching	Topic/Unit No.	Textbook [TB]/ Reference Book	Teaching-Learning
1	Unit 1: Introduction	TB-Chapters 1-2	Lectures, Discussions
2	Unit 1: Introduction	TB-Chapters 3-4	Lectures, Case Studies
3	Unit 2: Effect of Solid Waste Disposal on	TB-Chapters 5-6	Lectures, Group Discussions
4	Unit 2: Effect of Solid Waste Disposal on	TB-Chapters 7-8	Lectures, Case Studies
5	Unit 3: Solid Waste Management	TB-Chapters 9-10	Lectures, Guest Lecture
6	Unit 3: Solid Waste Management	TB-Chapters 11-12	Lectures, Practical
7	Unit 3: Solid Waste Management	TB-Chapters 13-14	Lectures, Field Trip
8	Unit 4: Industrial Waste Management	TB-Chapters 15-16	Lectures, Guest Lecture
9	Unit 4: Industrial Waste Management	TB-Chapters 17-18	Lectures, Case Studies
10	Unit 5: Resource Recovery	TB-Chapters 19-20	Lectures, Practical
11	Unit 5: Resource Recovery	TB-Chapters 21-22	Lectures, Group Discussions

12	Unit 6: Waste-to-Energy	TB-Chapters 23-24	Lectures, Guest Lecture
13	Unit 7: Integrated Waste Management	TB-Chapters 25-26	Lectures, Workshops
14	Unit 8: Lifecycle Assessment and Unit 9:	TB-Chapters 27-28	Lectures, Student

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Students will identify sources, types, and chemical compositions of solid waste, distinguishing hazardous and biomedical waste, and appreciate the importance of	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Students will analyze the environmental impact of improper waste disposal on water quality, ecosystems, soil, and human health, developing an understanding of the		
3	Students will learn techniques for collecting, transporting, and disposing of solid waste, including landfill design and thermal treatment. They'll understand the		
4	Students will assess the impact of industrial waste on air, water, and soil, exploring strategies for emission control and effluent treatment. They'll		
5	Students will grasp resource recovery methods like composting, anaerobic digestion, and recycling, realizing the potential of waste as a resource and its role		
6	Students will evaluate waste-to-energy processes such as combustion and anaerobic digestion, understanding how waste can be converted into energy		
7	Students will recognize the waste management hierarchy and the significance of integrated approaches for effective waste handling, aligning with		

8	Students will comprehend the cradle-to-grave approach of LCA, applying it to assess environmental impacts of waste management strategies and products.		
9	Students will gain insights into waste management policies, regulations, and the role of eco-friendly products in responsible waste handling practices.		

COURSE OBJECTIVES

The course will enable the student-teacher to:

1. Develop a comprehensive understanding of Environmental Impact Assessment (EIA) concepts, methodologies, and key stakeholders' roles in the assessment process.
2. Analyze and apply advanced techniques such as Rapid EIA, Strategic Environmental Assessment, and Social Impact Assessment to assess environmental implications of projects.
3. Evaluate the regulatory framework and current issues related to EIA in India, and critically assess case studies of hydropower and thermal projects.
4. Gain proficiency in Risk Assessment techniques, including exposure assessment, hazard identification, and risk communication, and comprehend the legal and regulatory aspects of environmental risk assessment.

COURSE OUTCOMES (CO)

UEV107	**Environmental Impact assessment and Risk assessment**	**L**	**T**	**P**	**C**
Version 3.0		**4**	**0**	**0**	**4**
Total Contact Hours	**60**				
Pre-requisites/Exposure	**Environmental risk assessment**				
Co-requisites	--				

- On completion of this course, the student-teacher will be able to:
- CO1: Recall and define key concepts and principles of Environmental Impact Assessment (EIA), including its methodologies, stakeholders, and regulatory framework in various project contexts.

- CO2: Apply advanced assessment techniques such as Rapid EIA, Social Impact Assessment, and Life Cycle Assessment to analyze real-world environmental scenarios and propose mitigation strategies.
- CO3: Analyze the complexities of EIA regulations and current issues in India, critically evaluate case studies of hydropower and thermal projects, and assess their environmental implications.
- CO4: Evaluate the effectiveness of Risk Assessment methodologies, interpret exposure and toxicity data, and assess the ecological and human risks associated with different projects, while considering legal and regulatory aspects

CATALOG DESCRIPTION

Explore the intricate realm of Environmental Impact Assessment (EIA) with this comprehensive course. Delve into the foundations of EIA, encompassing definitions, methodologies, and historical developments, while uncovering the pivotal roles of project proponents, developers, and consultants. Examine the multifaceted dimensions of EIA scope and prediction, delving into baseline data collection, Environmental Impact Statements (EIS), and Environmental Management Plans (EMP). Engage in rapid EIA and strategic assessments, and dissect the intricate interplay between environmental management principles, problems, and strategies.

COURSE CONTENT

Thiscourserecognizesthegrowingneedofindustrytoanticipateandincorporateenvironmental concerns and risks while developing large-scale projects. The course emphasizes on thecontemporarytoolsandtechniquestoassessvariousenvironmentalimpactsandoutlinesvariousmanagementoptions needed to mitigatetheserisks.

Unit 1: Environmental impact assessment (EIA): (15 Lectures)

Definitions, introduction and concepts; rationale andhistorical development of EIA; scope and methodologies of EIA; role of project proponents, projectdevelopers and consultants; Terms of Reference; impact identification and prediction; baseline datacollection;EnvironmentalImpactStatement(EIS),EnvironmentalManagementPlan(EMP)

Unit 2: (15 Lectures)

Rapid EIA; Strategic Environmental Assessment; Social Impact Assessment; Cost-Benefitanalysis; Life cycle assessment; environmental appraisal; environmental management - principles,problems and strategies; environmental planning; environmental audit; introduction to ISO and ISO14000;sustainabledevelopment.

Unit3: (15 Lectures)

EIAregulationsinIndia;statusofEIAinIndia;currentissuesinEIA;casestudyofhydropowerprojects/ thermal projects.

Unit 4: (15 Lectures)

Risk assessment: introduction and scope; project planning; exposure assessment; toxicityassessment;hazardidentificationandassessment;riskcharacterization;riskcommunication;environmentalmonitoring;communityinvolvement;legalandregulatoryframework;humanandecologicalrisk assessment.

Hands-on: Basedonthetheory.

SuggestedReadings

Barrow,C.J.2000.*SocialImpactAssessment:AnIntroduction*.OxfordUniversityPress.

Glasson,J.,Therivel,R.,Chadwick,A.1994.*IntroductiontoEnvironmentalImpactAssessment*.London,Research Press, UK.

Judith,P.1999.*HandbookofEnvironmentalImpactAssessment*.BlackwellScience.

Marriott,B.1997.*EnvironmentalImpactAssessment:APracticalGuide*.McGraw-Hill,NewYork, USA.

Open Educational Resources (OER)

- United Nations Environment Programme (UNEP) EIA Training Resource Manual
- International Association for Impact Assessment (IAIA) Resources
- World Bank Environmental and Social Framework
- Environmental Protection Agency (EPA) EIA Resources
- Asian Development Bank (ADB) Environmental Assessment Sourcebook
- United Nations Economic Commission for Europe (UNECE) EIA Training Materials
- World Health Organization (WHO) Environmental Impact Assessment Guidelines
- Environmental Law Institute (ELI) EIA Resources
- International Finance Corporation (IFC) EIA Guidelines
- United Nations Development Programme (UNDP) EIA Toolkit

Assessment & Evaluation

Components	Attendance	Quiz/Assignment/	Mid Term	End Term
Weightage (%)	10	20	20	50

Programme And Course Mapping

Course Code and Title	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
UEV107 Environm	CO1	3	2	2	3	1	2	2	2	2	1	3	1	2	1

ental Impact assessment and Risk Management	**CO2**	**2**	**3**	**2**	**2**	**1**	**2**	**2**	**2**	**2**	**1**	**2**	**3**	**2**	**1**
	CO3	**2**	**2**	**3**	**3**	**1**	**3**	**2**	**2**	**2**	**1**	**3**	**2**	**3**	**2**
	CO4	**2**	**2**	**2**	**3**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**3**

Unit I	**Introduction**
Local	-
Regional	-
National	-
Global	Recognizing global waste management challenges and solutions.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in assessing and mitigating the environmental impact of waste disposal.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit II	**Effect of Solid Waste Disposal on Environment**
Local	-
Regional	-
National	-
Global	Ingredient in Research and Analysis
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in waste characterization, collection, and disposal.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
Unit III	**Solid Waste Management**
Local	-
Regional	-

National	-
Global	Recognizing global best practices in solid waste management.
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Promoting sustainable waste management practices and reducing environmental impact.-
Unit IV	**Industrial Waste Management**
Local	Understanding local industrial waste types and their impact on air, water, and soil quality.
Regional	-
National	-
Global	Recognizing global environmental concerns related to industrial waste pollution.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in EIA regulations, compliance assessment, and case study analysis.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	Universal quality education and lifelong learning (SDG 4.4)
NEP	India's Higher Education System (9.1- 9.3), Promoting High Quality research (18.1-18.9); Technology Use and Integration (23.1-23.13)
POE/4TH IR	Global Education Knowledge, Technical Skill that match Industry Needs, Focus on Emloyability Skills (Regional/ Global), Internship Program, On Campus Job

Teaching Plan:

Week	Topic or Unit No.	Textbook/Reference Book	OER	Teaching-Learning

				Method
1	Unit 1: EIA Definitions and Concepts	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 1)	-	Lecture, Discussion
2	Unit 1: Rationale and Historical Development of EIA	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 2)	-	Lecture, Case Study
3	Unit 1: Scope and Methodologies of EIA	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 3)	-	Lecture, Group Activity
4	Unit 1: Role of Project Proponents, Developers, and Consultants	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 4)	-	Lecture, Guest Lecture
5	Unit 1: Terms of Reference and Impact Identification	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 5)	-	Lecture, Discussion
6	Unit 1: Baseline Data Collection and EIS	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 6)	-	Lecture, Case Study
7	Unit 1: Environmental Management Plan	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 7)	-	Lecture, Group Activity
8	Unit 2: Rapid EIA and Strategic Environmental Assessment	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 8)	-	Lecture, Guest Lecture
9	Unit 2: Social Impact Assessment and Cost-Benefit Analysis	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 9)	-	Lecture, Case Study
10	Unit 2: Life Cycle Assessment and Environmental Appraisal	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 10)	-	Lecture, Group Activity
11	Unit 2: Environmental Management Principles and Strategies	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 11)	-	Lecture, Discussion

12	Unit 2: Environmental Planning and Environmental Audit	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 12)	-	Lecture, Case Study
13	Unit 2: Introduction to ISO and ISO 14000	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 13)	-	Lecture, Group Activity
14	Unit 2: Sustainable Development and Review	Textbook: Environmental Impact Assessment: A Guide to Best Professional Practices (Chapter 14)	-	Lecture, Discussi on

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
Unit 1	CO1: Understand EIA definitions, concepts, and historical development	Lecture, Discussion on EIA concepts, historical examples	Quiz, Class Participation
	CO2: Analyze the role of project proponents, developers, and consultants in EIA process	Guest Lecture, Case Studies on project roles	Group Presentation, Case Study Analysis
	CO3: Demonstrate understanding of EIA methodologies, impact identification, and prediction	Workshop on EIA methodologies, Impact Identification Exercise	Group Exercise, Written Assignment
	CO4: Evaluate the significance of Terms of Reference, baseline data collection, and EIS in EIA process	Analysis of EIS documents, Group Discussion	EIS Review, Group Presentation
Unit 2	CO1: Understand Rapid EIA and Strategic Environmental Assessment	Lecture on Rapid EIA and SEA, Case Studies	Quiz, Case Study Analysis
	CO2: Analyze Social Impact Assessment and	Guest Lecture on SIA, CBA, Group	Group Presentation,

	Cost-Benefit Analysis	Discussions	Debate
	CO3: Apply Life Cycle Assessment and Environmental Appraisal	Workshop on LCA, Environmental Appraisal Exercise	Group Exercise, Written Assignment
	CO4: Evaluate Environmental Management Principles, Strategies, Planning, and Audit	Group Activities on Environmental Management, Lecture on Audit	Group Presentation, Audit Report Review
Unit 3	CO1: Understand EIA regulations in India and the status of EIA implementation	Lecture on EIA regulations, Discussion on case studies	Quiz, Case Study Analysis
	CO2: Analyze current issues in EIA and case studies of hydropower/thermal projects	Guest Lecture on current issues, Case Study Discussions	Group Presentation, Case Study Analysis
	CO3: Apply knowledge of EIA regulations and issues to real-life scenarios	Workshop on EIA regulations, Role-Play scenarios	Role-Play Assessment, Group Discussion
	CO4: Evaluate the impact assessment process and legal/regulatory frameworks	Analysis of legal frameworks, Discussion on regulatory compliance	Written Assignment, Class Participation
Unit 4	CO1: Understand risk assessment and its components	Lecture on Risk Assessment, Discussion on key components	Quiz, Class Discussion
	CO2: Analyze project planning, exposure assessment, and toxicity identification	Guest Lecture on exposure assessment, Workshop on toxicity assessment	Group Presentation, Workshop Report
	CO3: Apply hazard identification, risk characterization, and communication techniques	Hazard Identification Exercise, Role-Play on Risk Communication	Group Exercise, Role-Play Assessment
	CO4: Evaluate environmental monitoring, community	Case Studies on monitoring, Guest Lecture on	Case Study Analysis, Group Presentation

	involvement, and human/ecological risk assessment	community involvement	

UEV108	SDG'S AND CLIMATE CHANGE	L	T	P	C
Version 1.0		**4**	**0**	**0**	**4**
Total Contact Hours	**60**				
Pre-requisites/Exposure	**Basics of Chemistry**				
Co-requisites	--				

Course Description

1. To enable the students to understand climate change, and their causes.
2. To enable the student to Sustainable Development in theory and practice.

COURSE LEARNING OUTCOMES

Upon completion of this course, students will be able to:

CO1: demonstrate an understanding of the manifestations and causes of climate change, including both natural and anthropogenic factors.
CO2: analyze and assess climate risks and vulnerability in different regions, such as India and Central Asia, using appropriate assessment methods.
CO3: critically evaluate global responses to sustainable development, including the Sustainable Development Goals (SDGs) and international conventions like the Paris Agreement.
CO4: demonstrate the ability to propose and design comprehensive sustainability governance frameworks, considering the cross-cutting issues of power, knowledge, and norms.

COURSE CONTENT

Unit I: **(10 lectures)**

Global Warming and Climate Change, Debate on Climate Change – the manifestations of Climate Change; Natural and anthropogenic (human interventions), Relationship between socioeconomic and environmental drivers of change (e.g. globalization, urbanization, land degradation, inefficient use of water, climate change), Climate change: Adaptation and Mitigation Strategies at International and national contexts , International and National Efforts at Carbon Emission Reductions, Global (environmental) change and sustainable development, and sustainable development with a focus on the specific situation in Central Asia

Case study 1: Assessment of climate risks and vulnerability in India, Presentation of national assessment results and vulnerability maps and preparation of an assessment in the pilot area.

Unit II **(12 lectures)**

Sustainable Development in theory and practice, Global Responses to Sustainable Development, Sustainable Development Goals (vs Millennium Development Goals), The Paris and Post-Paris Convention on Climate Change and Sustainable Development , Triple Bottom line of Sustainability: Food, Water, Energy nexus, Potential and Barriers to Sustainable Business, Sustainable rural and urban livelihoods, Laying Out Actors and Dynamics in the 2030 Agenda for Sustainable Development

Unit III **(8 lectures)**

Climate Risks and Vulnerability Assessment of India, Why environment and natural resources are prone to market failure, Values (Economic or otherwise) of Environment and Natural Resources: Use, Option, Existence, Signals of Natural Resource Depletion/ scarcity and valuation methods (Health cost, amenities and Hedonic Pricing, Travel Cost methods, Contingent Valuation Methods, Choice Experiments, Limitations of these signals), Payment for Ecosystem Services (PES), Combining Theories of Governing Societal Change towards Sustainability

Unit IV **(12 lectures)**

Governance Pillars and Competences: Power, Knowledge and Norms as Cross-Cutting Issues in Governance for the SDGs, Socially and Environmentally Responsible Business Management, The relevance of Green Growth Green Business paradigms, Environmental Values of Business, Corporate Social Responsibility and Environmental Impacts, Environmental Risk Management & Environmental Strategy, Environmental and Ecological Stewardship, Inferences on Improving Integrative Sustainability Governance

Case Study 1: Sustainable Disaster Risk Reduction in Mountain Agriculture: Agroforestry Experiences in Kaule, Mid-Hills of Nepal

Case study 2: Climate Change 2014, Impacts, Adaptation, and Vulnerability Part A: Global and Sectoral Aspects. Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Case study 3: Influence of Climate Change on Environmental Hazards and Human Well-Being in the Urban Areas—Warsaw Case Study Versus General Problems

References books

1. Jacob Thomas, Environmental Management – Text and Cases, Dorling Kindersley (India) Pvt. Ltd. 2014.
2. Environmental Management, Sustainable Development and Human Health, (Eds.) [2009], Eddie N. Laboy-Nieves & Fred C. Schaffner; Ahmad H. Abdelhadi; Mattheus F. A. Goosen, CRC Press/Balkema is an imprint of the Taylor & Francis Group, London, UK, 596p.

Open Educational Resources (OER)

- https://www.climate.gov/
- https://unfccc.int/
- https://sustainabledevelopment.un.org/
- https://ocw.mit.edu/index.htm
- https://www.open.edu/openlearn/science-maths-technology/environmental-studies/climate-change-and-global-warming/content-section-0
- https://open.umn.edu/opentextbooks/textbooks/environmental-science
- https://www.unep.org/library
- https://www.greengrowthknowledge.org/
- https://www.wri.org/
- https://openknowledge.worldbank.org/

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Attendance	Quiz/Assignment/	Mid Term	End Term
Weightage (%)	10	20	20	50

Programme and Course Mapping

Course Code and	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4

Title	(CO)														
UEV 108 SDG'S AND CLIMATE	CO1	3	1	1	3	1	1	3	2	2	1	2	1	1	1
	CO2	1	3	2	2	2	3	1	3	1	3	3	1	3	2
	CO3	1	2	3	2	1	2	2	3	1	2	2	1	2	2
	CO4	2	2	1	3	1	3	1	1	2	2	3	2	2	2

1=weakly mapped
2= moderately mapped
3=strongly mapped

Unit I	**GlobalGlobal Warming and Climate Change Warming and Climate Change**
Local	Understanding local impacts of global warming and climate change on communities and ecosystems.
Regional	-
National	-
Global	Recognizing global challenges and solutions related to climate change and sustainable development.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in climate risk assessment, adaptation, and mitigation strategies.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Promoting responsible environmental practices for climate resilience and sustainable development.
Unit II	**Sustainable Development in theory and practice**
Local	-
Regional	-
National	-
Global	Recognizing global initiatives and conventions related to sustainable development and climate change.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in sustainable development theory, planning, and evaluation.

Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Promoting responsible environmental practices for sustainable business and livelihoods.
Unit III	**Climate Risks and Vulnerability Assessment of India**
Local	-
Regional	-
National	-
Global	Recognizing global approaches to valuing environment and natural resources for sustainability.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in climate risk assessment methodologies, valuation techniques, and sustainability economics.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Promoting responsible environmental valuation and sustainable resource management.
Unit IV	**Governance Pillars and Competences**
Local	-
Regional	-
National	-
Global	Recognizing global governance principles for environmental sustainability.
Employability	-
Entrepreneurship	-
Skill Development	Developing expertise in governance frameworks, sustainability principles.
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	Promoting responsible governance for environmental protection and sustainable resource management.
SDG	4.3 technical & Vocational Skill
NEP	Promoting High Quality research (18.1-18.9)

POE/4th IR	Reflective and Constructivist Approach of learning

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Methods
Week 1	Introduction to Environmental Management	Jacob Thomas, Environmental Management – Text and Cases https://www.climate.gov/	Lecture, Class Discussion
Week 2	Climate Change and Global Warming	Jacob Thomas, Environmental Management – Text and Cases https://unfccc.int/	Lecture, Audio-Visual Aids
Week 3	Sustainable Development and Human Health	Environmental Management, Sustainable Development and Human Health https://sustainabledevelopment.un.org/	Lecture, Case Studies
Week 4	Manifestations of Climate Change	Jacob Thomas, Environmental Management – Text and Cases https://ocw.mit.edu/index.htm	Lecture, Group Activities
Week 5	Natural and Anthropogenic Drivers of Climate Change	Jacob Thomas, Environmental Management – Text and Cases https://www.open.edu/openlearn/science-maths-technology/environmental-studies/climate-change-and-global	Lecture, Debates
Week 6	Socioeconomic and Environmental Drivers of Change	Environmental Management, Sustainable Development and Human Health https://open.umn.edu/opentextbooks/textbooks/environmental-science	Lecture, Class Discussion
Week 7	Climate Change Adaptation and Mitigation Strategies	Jacob Thomas, Environmental Management – Text and Cases https://www.unep.org/library	Lecture, Guest Speaker

Week 8	International Efforts on Carbon Emission Reductions	Jacob Thomas, Environmental Management – Text and Cases https://www.greengrowthknowledge.org/	Lecture, Video Presentation
Week 9	Global Environmental Change and Sustainable Development	Environmental Management, Sustainable Development and Human Health https://www.wri.org/	Lecture, Group Projects
Week 10	Sustainable Development Goals (SDGs)	Jacob Thomas, Environmental Management – Text and Cases https://openknowledge.worldbank.org/	Lecture, Class Discussion
Week 11	Paris and Post-Paris Convention on Climate Change	Jacob Thomas, Environmental Management – Text and Cases	Lecture, Case Studies
Week 12	Triple Bottom Line of Sustainability	Environmental Management, Sustainable Development and Human Health	Lecture, Role-Play
Week 13	Sustainable Rural and Urban Livelihoods	Jacob Thomas, Environmental Management – Text and Cases	Lecture, Guest Speaker
Week 14	Integrative Sustainability Governance	Environmental Management, Sustainable Development and Human Health	Lecture, Final Exam Review

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning Outcomes (CLOs)	Teaching-Learning Activities	Assessment Task Methods

1	• Understand the manifestations of climate change • Explain natural and anthropogenic drivers of change • Analyze the relationship between socioeconomic and environmental drivers of	• Lecture, Audio-Visual Aids, Case Studies • Group Activities, Debates, Guest Speaker • Class Discussion, Role-Play, Video Presentation • Case Studies, Guest Speaker, Group	• Class Discussion, Quizzes, Case Study Analysis • Group Presentations, Debate Assessment • Written Assignment, Role-Play Assessment • Case Study
2	• Explore the concept of sustainable development • Compare Sustainable Development Goals (SDGs) with Millennium Development Goals • Analyze the Paris and Post-Paris Convention on Climate Change and Sustainable Development	• Lecture, Class Discussion, Audio-Visual Aids • Group Activities, Case Studies, Debates • Lecture, Video Presentation, Class Discussion • Role-Play, Case Studies, Guest Speaker	• Class Participation, Concept Mapping • Group Presentations, Debate Assessment • Written Assessment, Video Presentation • Role-Play
3	• Evaluate the concept of climate risks and vulnerability assessment • Analyze the values and signals of natural resource depletion/scarcity • Explore Payment for Ecosystem Services (PES) • Examine theories of governing societal change	• Lecture, Class Discussion, Case Studies • Group Activities, Guest Speaker, Video Presentation • Case Studies, Role-Play, Guest Speaker • Class Discussion, Video Presentation, Guest Speaker	• Class Participation, Written Assignment • Group Presentations, Video Presentation • Role-Play Assessment, Case Study Analysis • Class
4	• Understand governance pillars and competences • Analyze socially and environmentally responsible business management • Explore the relevance of green growth and green business paradigms	Lecture, Audio-Visual Aids, Class Discussion Group Activities, Case Studies, Guest Speaker Debate, Role-Play, Guest Speaker Case Studies, Group Projects, Class Discussion	• Class Participation, Quizzes • Group Presentations, Case Study Analysis • Debate Assessment, Role-Play Assessment

Syllabus of Minor-Nano Science

UNS101	Study of Materials	L	T	P	C
Version 1.0		4	0	0	4
Total Contact Hours	60				
Pre-requisites/Exposure					
Co-requisites	--				

Course Objective: All the modern modern materials show some unique properties which either are by the virtue of material or may be tailored. Metallurgists and Materials scientists are responsible for designing and producing new materials. The desired properties may be introduced in the materials by altering their microstructures. This course will help students understand the properties of different types of materials and their applications. The course will also helpful to develop new kind of materials for engineering applications.

Course Outcomes:

CO1: Understand the mechanical properties of metals, including stress-strain behavior, plastic deformation, and hardness.

CO2: Analyze dislocations and strengthening mechanisms in metals, including grain size reduction and strain hardening.

CO3: Describe the solid solutions and phase diagrams, including unary & binary phase diagrams and eutectic systems.

CO4: Examine the failures of metals, including fracture, fatigue, creep, and corrosion mechanisms and prevention.

UNIT I

Mechanical Properties of Metals **15**

Lectures hours

Concepts of Stress and Strain, Elastic Deformation: Stress-Strain Behavior, Anelasticity, Elastic Properties of Materials; Plastic Deformation: Tensile Properties, True Stress and Strain, Elastic Recovery after Plastic Deformation, Compressive, Shear, and Torsional Deformation, Hardness; Property Variability And Design/Safety Factors: Variability of Material Properties, Design/Safety Factors.

UNIT II

Dislocations and Strengthening Mechanisms

Characteristics of Dislocations, Slip Systems, Slip in Single Crystals, Plastic Deformation of Polycrystalline Materials, mechanism of plastic deformation, deformation by twinning,

Mechanisms Of Strengthening In Metals: Strengthening by Grain Size Reduction, 7.9 Solid-Solution Strengthening, Strain Hardening; Recovery, Recrystallization and Grain Growth: Recovery, Recrystallization, Grain Growth.

UNIT III **15**

Lectures Hours

Solid solutions and phase diagram

Introduction to single and multiphase solid solutions and types of solid solutions, importance and objectives of phase diagram, systems, phase and structural constituents, cooling curves, unary & binary phase diagrams, Gibbs's phase rule, Lever rule, eutectic and eutectoid systems, peritectic and peritectoid systems, iron carbon equilibrium diagram and TTT diagram.

UNIT IV **15**

Lectures Hours

Failures of metals

Failure analysis, fracture, process of fracture, types of fracture, fatigue, characteristics of fatigue, fatigue limit, mechanism of fatigue, factors affecting fatigue.

Definition and concept of Creep, creep curve, mechanism of creep, impact of time and temperature on creep, creep fracture, creep testing and prevention against creep.

Corrosion: Mechanism and effect of corrosion, prevention of corrosion

TEXT BOOKS:

1. Materials Science and Engineering:An Introduction (7th Ed.), William D. Callister, Jr., John Wiley & Sons, Inc.
2. Elements of Material Science and Engineering: VanVlack, Wesley Pub. Comp.
3. Material Science - Narula, Narula and Gupta. New Age Publishers

REFERENCE BOOKS:

1. Material Science & Engineering –V. Raghvan, Prentice Hall of India Pvt. Ltd, New Delhi.
2. A Text Book of Material Science & Metallurgy – O.P. Khanna, DhanpatRai& Sons
3. Engineering Materials: Kenneth G. Budinski, Prentice Hall of India, New Delhi

Open Educational Resources (OER)

https://www.govinfo.gov/content/pkg/GOVPUB-C13-e18ffcc1681da9e902df23acaeb5cc6c/pdf/GOVPUB-C13-e18ffcc1681da9e902df23acaeb5cc6c.pdf
https://uomustansiriyah.edu.iq/media/lectures/6/6_2018_05_19!12_50_38_AM.pdf

Assessment & Evaluation

Components	Assignment	Mid Term	Attendance	End Term
Weightage (%)	20	20	10	50

ProgrammeAnd Course Mapping

Course Code and Title	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4

UNS101	CO1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Study of Materials	CO2	2	3	2	2	2	2	2	2	2	2	2	2	2	2
	CO3	2	2	3	2	2	2	2	2	2	2	2	2	2	2
	CO4	2	2	2	3	2	2	2	2	2	2	2	2	2	2

1=lightly mapped 2= moderately mapped 3=strongly mapped

Course Content: Mechanical Properties of Metals (Unit I)

Indicator	Relevant Course Content
Local	Concepts of Stress and Strain, Elastic Deformation, Plastic Deformation, Tensile Properties, True Stress and Strain, Hardness, Variability of Material Properties
Regional	-
National	Concepts of Stress and Strain, Elastic Deformation, Plastic Deformation, Tensile Properties, True Stress and Strain, Hardness, Variability of Material Properties
Global	Concepts of Stress and Strain, Elastic Deformation, Plastic Deformation, Tensile Properties, True Stress and Strain, Hardness, Variability of Material Properties
Employability	Concepts of Stress and Strain, Elastic Deformation, Plastic Deformation, Tensile Properties, True Stress and Strain, Hardness, Variability of Material Properties
Entrepreneurship	-
Skill Development	Concepts of Stress and Strain, Elastic Deformation, Plastic Deformation, Tensile Properties, True Stress and Strain, Hardness
Professional Ethics	-
Gender	-
Human Values	-
Environment &	-

Sustainability	
SDG	-
Nep 2020	-
Poe/4th IR	-

Course Content: Dislocations and Strengthening Mechanisms (Unit II)

Indicator	Relevant Course Content
Local	Characteristics of Dislocations, Slip Systems, Plastic Deformation, Mechanisms Of Strengthening In Metals, Recovery, Recrystallization and Grain Growth
Regional	-
National	Characteristics of Dislocations, Slip Systems, Plastic Deformation, Mechanisms Of Strengthening In Metals, Recovery, Recrystallization and Grain Growth
Global	Characteristics of Dislocations, Slip Systems, Plastic Deformation, Mechanisms Of Strengthening In Metals, Recovery, Recrystallization and Grain Growth
Employability	Characteristics of Dislocations, Plastic Deformation, Mechanisms Of Strengthening In Metals, Recovery, Recrystallization and Grain Growth
Entrepreneurship	-
Skill Development	Characteristics of Dislocations, Plastic Deformation, Mechanisms Of Strengthening In Metals, Recovery, Recrystallization and Grain Growth
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	-
Nep 2020	-
Poe/4th IR	-

Course Content: Solid Solutions and Phase Diagrams (Unit III)

Indicator	Relevant Course Content
Local	-
Regional	-
National	Introduction to solid solutions, Phase Diagrams, Gibbs's phase rule, Lever rule, Iron-Carbon Equilibrium Diagram

Global	Introduction to solid solutions, Phase Diagrams, Gibbs's phase rule, Lever rule, Iron-Carbon Equilibrium Diagram
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	-
Nep 2020	-
Poe/4th IR	-

Course Content: Failures of Metals (Unit IV)

Indicator	**Relevant Course Content**
Local	Failure analysis, Fracture, Fatigue, Creep, Creep Testing, Prevention against Creep
Regional	-
National	Failure analysis, Fracture, Fatigue, Creep, Creep Testing, Prevention against Creep
Global	Failure analysis, Fracture, Fatigue, Creep, Creep Testing, Prevention against Creep
Employability	Failure analysis, Fatigue, Creep, Prevention against Creep
Entrepreneurship	-
Skill Development	Failure analysis, Fatigue, Creep
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	-
Nep 2020	-
Poe/4th IR	-

Teaching Plan:

Week	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ OER	Teaching-Learning Method
1	Concepts of Stress and Strain, Elastic Deformation	TB1, OER1	Lecture, Conceptual Explanation
2	Plastic Deformation, Tensile Properties, True Stress and Strain	TB1, OER1	Lecture, Examples, Problem Solving
3	Compressive, Shear, and Torsional Deformation, Hardness	TB1, OER1	Lecture, Practical Examples, Lab Work
4	Property Variability and Design/Safety Factors	TB1, OER2	Lecture, Case Studies
5	Characteristics of Dislocations, Slip Systems	TB1, OER2	Lecture, Case Studies, Discussions
6	Slip in Single Crystals, Plastic Deformation of Polycrystalline Materials	TB1, OER2	Lecture, Examples, Graphical Representation
7	Mechanisms of Strengthening in Metals: Grain Size Reduction, Solid-Solution Strengthening	TB1, OER2	Lecture, Conceptual Exercises, Discussions
8	Strain Hardening; Recovery, Recrystallization, and Grain Growth	TB1, OER2	Lecture, Practical Examples, Lab Work
9	Introduction to Solid Solutions and Phase Diagrams	TB1, OER2	Lecture, Examples, Problem Solving
10	Unary and Binary Phase Diagrams, Gibbs's Phase Rule	TB1, OER2	Lecture, Case Studies, Problem-Solving Sessions
11	Lever Rule, Eutectic and Eutectoid Systems	TB1, OER2	Lecture, Case Studies, Group Discussions
12	Peritectic and Peritectoid Systems, Iron-Carbon Equilibrium Diagram	TB1, OER2	Lecture, Examples, Graphical Representation
13	TTT (Time-Temperature-Transformation) Diagram, Failure Analysis	TB1, OER2	Lecture, Case Studies, Discussions
14	Creep and Fatigue Mechanisms, Prevention Against Creep	TB1, OER2	Lecture, Practical Examples, Lab Work

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes (CO)	Teaching-Learning Activities	Assessment Task Methods
I	Understand the concepts of stress and strain	- Lectures	➢ Presentations

	and their relevance to mechanical properties of metals	- Presentations - Problem-Solving Sessions	and class discussions. ➢ Assignments and class tests. ➢ Student presentations. ➢ Mid-term examinations. ➢ End-term examinations
II	Describe dislocations and their role in plastic deformation of materials.	- Lecture - Discussions - Problem-Solving Sessions	
III	Introduce the concept of solid solutions and phase diagrams in materials	- Lecture - Problem-Solving Sessions - Practical Exercises	
IV	Analyze the failures of metals, including fracture, fatigue, and creep mechanisms	Group presentations on preventive measures and case studies. - Lecture - Problem-Solving Sessions	

UNS102	Elements of Nano sciences and nanomaterial	L	T	P	C
Version 1.0		4	0	0	4
Total Contact Hours	60				

Pre-requisites/Exposure	Basics of Chemistry
Co-requisites	--

Course Description

The aim of this course is to introduce an emerging class of materials called nanomaterials that consists of a broad spectrum of examples with at least one dimension in the range of 1 to 100 nm. Exceptionally high surface areas can be achieved through the rational design of nanomaterials. It will also explain how nanomaterials can be produced with outstanding magnetic, electrical, optical, mechanical, and catalytic properties that are substantially different from their bulk counterparts. The course will conclude with various types of characterization techniques which can be used for analysing these nanomaterials.

Course Outcomes

CO1: Learning about the background of nanoscience and understanding how it has been existent in nature since ages.

CO2: Knowledge about quantum mechanics and applying it understanding nano effects.

CO3: Analysing various ways of synthesising nanomaterial.

CO4: Evaluating ways for the structure and properties of nanomaterials.

Unit I **15 Lectures**

Background to Nano science: Definition of Nano, Scientific revolution-atomic Structure and atomic size, emergence and challenges of nano science and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of Nano over micro/macro, size effects and crystals, large surface to volume ratio, surface effects on the properties. Influence of Nano structuring on Mechanical, optical, electronic, magnetic and chemical properties.

Unit-II **15 Lectures**

Introduction to Quantum Mechanics: Schrodinger equation and expectation values, Solutions of the Schrodinger equation for free particle, particle in a box, particle in a finite well, Reflection and transmission by a potential step and by a rectangular barrier. Angular momentum and its operators, Eigen values and Eigen functions of the angular momentum operators, spin, Pauli spin operators and their properties, hydrogen atom, density of states, free electron theory of metals.

Unit III **15 Lectures**

Types of nanostructure and properties of nanomaterial: One dimensional, two dimensional and three dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties.

Chemical synthesis of nano material: Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, colloids, zeolites, organic block copolymers, emulsion polymerization, template synthesis, and confined nucleation and/or growth. Biomimetic Approaches: polymer matrix isolation, and surface-template nucleation and/or crystallization. Vapour (or solution) – liquid – solid (VLS or SLS) growth -Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition

Unit IV **15 Lectures**

Characterization of nanomaterial: X-ray Diffraction - Thermal Analysis Methods, Differential Thermal Analysis and Differential scanning calorimetry - Spectroscopic techniques, UV-Visible Spectroscopy – IR Spectroscopy – Microwave Spectroscopy - Raman **Spectroscopy:** Electron Spin Resonance Spectroscopy, NMR Spectroscopy, **Particle size characterization:** Zeta Potential Measurement, **Particle size Analysis:** X-ray Photoelectron spectroscopy. **Imaging techniques for nanotechnology**: Scanning Electron Microscopy, Transmission Electron Microscopy, and Atomic Force Microscopy.

Textbooks

TB1 : Nanomaterials Chemistry by Rao C. N., A. Muller, A. K. Cheetham,, WileyVCH , 2007.

TB2: Nanomaterials and Nanochemistry by Brechignac C., P. Houdy, M. Lahmani, Springer publication, 2007.

TB3: Nanoscale materials in chemistry by Kenneth J. Klabunde, Wiley Interscience Publications, 2001.

TB4: Nanochemistry by Sergeev G.B., Elseiver publication, 2006.

TB5: Quantum Physics – A. Ghatak

Reference Books

RB1: Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.

RB2: Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.

RB3: Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830- 831, Cambridge University Press.

RB4: Processing & properties of structural naonmaterials- Leon L. Shaw, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.

Open Educational Resources (OER)

https://www.youtube.com/watch?v=0EWCqCIsFOA

https://www.youtube.com/watch?v=-K7Gs0Nj-5o&list=PLQzUXa8lZVq y0i5dOjW6oEr6h43bJCV
https://nptel.ac.in/courses/118104008
https://nptel.ac.in/courses/115101007

Assessment & Evaluation

Components	Assignment	Mid Term	Attendance	End Term
Weightage (%)	20	20	10	50

ProgrammeAnd Course Mapping

Course Code and Title	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
UNS102/ Elements of Nano sciences and nanomaterial	CO1	3	1	1	2	1	1	1	1	1	1	3	1	1	1
	CO2	3	2	1	2	1	2	1	2	2	2	3	2	2	2
	CO3	3	1	2	3	3	2	3	2	1	3	3	3	2	3
	CO4	3	1	1	2	1	2	1	2	2	2	3	2	2	2

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped

RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

Unit i	**Background to Nano science**
Local	Understanding the impact of nanoscience on local industries and research.
Regional	-
National	Advancing national capabilities in nanotechnology research and quantum

	mechanics understanding.
Global	Contributing to global scientific advancements and collaborations in nanoscience.
Employability	Equipping students with knowledge of emerging nanotechnology trends.
Entrepreneurship	Facilitating innovation in nanotechnology-related startups.
Skill development	Developing analytical and research skills in nanoscience.
Professional ethics	Encouraging ethical conduct in nanotechnology research.
Gender	-
Human values	-
Environment & sustainability	Exploring sustainable nanomaterials and their applications.
Unit ii	**Introduction to Quantum Mechanics**
Local	Enabling local industries to adopt quantum mechanics principles in materials research.
Regional	-
National	Strengthening the understanding of quantum mechanics in national research.
Global	Enhancing global knowledge in quantum mechanics for advanced technologies.
Employability	Equipping students with quantum mechanics skills for diverse careers.
Entrepreneurship	Fostering innovation in quantum technology startups.
Skill development	Developing problem-solving skills in quantum mechanics.
Professional ethics	Promoting ethical research in quantum mechanics.
Gender	-
Human values	-
Environment & sustainability	Exploring quantum solutions for environmental challenges.
Unit iii	**Types of nanostructure and properties of nanomaterial**
Local	Promoting the local production of nanomaterials with specific properties.
Regional	-

National	Advancing national nanomaterial research and development.
Global	Contributing to global advancements in nanomaterial science.
Employability	Enhancing students' employability in nanotechnology-related fields.
Entrepreneurship	Encouraging innovation in nanomaterial startups.
Skill development	Developing synthesis and characterization skills in nanomaterials.
Professional ethics	Emphasizing ethical considerations in nanomaterial research.
Gender	-
Human values	-
Environment & sustainability	Investigating sustainable nanomaterials and processes.
Unit iv	**Characterization of nanomaterial**
Local	Offering local industries access to nanomaterial characterization techniques.
Regional	-
National	Strengthening national capabilities in nanomaterial characterization.
Global	Contributing to global knowledge in nanomaterial characterization.
Employability	Enhancing students' employability in materials analysis fields.
Entrepreneurship	Facilitating innovation in nanomaterial characterization services.
Skill development	Developing expertise in advanced characterization techniques.
Professional ethics	Promoting ethical conduct in nanomaterial characterization.
Gender	-
Human values	-
Environment & sustainability	Ensuring environmentally responsible nanomaterial analysis.
SDG	Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9)
Nep 2020	Towards a more holistic and multidisciplinary education Promoting high-quality research
Poe/4th IR	Preparing students for the Fourth Industrial Revolution.

Teaching Plan:

Week	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page	Teaching-Learning Method
1	Background to Nano Science	TB 1	Lecture, Presentation
2	Introduction to Quantum Mechanics	TB 1	Lecture, Problem Solving
3	Types of Nanostructure and Properties of Nanomaterials	TB 1	Lecture, Case Studies
4	Chemical Synthesis of Nanomaterials	TB 2	Lab Demonstrations, Hands-on Activities
5	X-ray Diffraction and Thermal Analysis Methods	TB 2	Lecture, Lab Work
6	Spectroscopic Techniques for Nanomaterial Characterization	TB 3	Lecture, Guest Lectures
7	Imaging Techniques for Nanotechnology	TB 3	Lab Work, Demonstrations
8	Schrodinger Equation and Expectation Values	https://nptel.ac.in/courses/118104008	Lecture, Problem Solving
9	Reflection and Transmission by Potential Barriers	RB 1	Lecture, Case Studies
10	One-Dimensional Nanostructured Materials	https://nptel.ac.in/courses/115101007	Lecture, Presentation
11	Spin and Pauli Spin Operators	RB 1	Lecture, Problem Solving
12	Two-Dimensional and Three-Dimensional Nanostructured Materials	RB 1	Lecture, Guest Lectures
13	Metal Oxides, Semiconductors, and Composites	https://nptel.ac.in/courses/115101007	Independent Study, Discussions
14	Nanomaterial Structure and Properties Evaluation	RB 3	Independent Study, Discussions

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes (CO)	Teaching-Learning Activities	Assessment Task Methods
I	Learn about the background of nanoscience and understand its existence in nature since ages and Apply knowledge of quantum mechanics to understand nano effects.	- Lectures - Presentations - Discussions	➢ Presentations and class discussions. ➢ Assignments and class tests. ➢ Student presentations. ➢ Mid-term examinations. ➢ End-term examinations
II	Apply knowledge of quantum mechanics to understand nano effects and Analyze various ways of synthesizing nanomaterials.	- Lab Demonstrations - Hands-on Activities - Case Studies	
III	CO3: Analyze various ways of synthesizing nanomaterials and Evaluate ways for the structure and properties of nanomaterials.	- Lecture - Guest Lectures - Independent Study	
IV	Evaluate ways for the structure and properties of nanomaterials.	- Lab Work - Demonstrations - Discussions	

UNS103	**Nanostructured materials**	L	T	P	C
Version 1.0		4	0	0	4
Total Contact Hours	60				

Pre-requisites/Exposure	Basics of nanomaterial
Co-requisites	--

Course Description

The aim of this course is make students understand the importance of nanostructured materials. Nanostructured materials have gained prominence in **technological advancements** due to their tunable physicochemical characteristics such as melting point, wettability, electrical and thermal conductivity, catalytic activity, light absorption and scattering resulting in enhanced performance over their bulk counterparts. Knowledge about these emerging materials will further help the students to explore these materials for advanced real life applications.

Course Outcomes

CO1: To recall the basics of Nano science and nanomaterial.

CO2: To understand about various applications of nanostructured materials

CO3: Analysing various technique for fabricating thin films

CO4: Evaluating the properties ofNano composites.

Unit I: **15 Lectures**

Nano Composites and their Applications, Metal-Metal Nano composites for nuclear energy applications, Magnetic Nano composites for Spintronics application, Ceramic Nano composites for high temperature applications. Length, energy, and time scales - Quantum confinement of electrons in semiconductor nanostructures: Quantum confinement in 3D, 2D, 1D and zero dimensional structures -Size effect and properties of nanostructures, Top down and Bottom up approach.

Unit II: **15 Lectures**

Nano ceramics: Dielectrics, ferroelectrics and magneto ceramics, Nano polymers: Preparation and characterization of diblock Copolymer based Nano composites, Nanoparticles polymer ensembles; Applications of Nano polymers in Catalysis.

Unit III: **15 Lectures**

Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods of the synthesis of conducting polymers – Applications of conducting polymers in corrosion protection, sensors, electronic and electrochemical energy devices.

Unit IV: **15 Lectures**

Miscellaneous applications of nanotechnology: dental implants, consumer products, biomimetic nanomaterial for tissue engineering, biopolymer tagging, semiconductor quantum dots.

Thin Film Formation Methods- Physical methods: thermal evaporation - vapour sources - Wire, crucible and electron beam gun - sputtering mechanism and methods - epitaxy - MBE. Chemical methods: chemical vapour deposition and chemical solution deposition techniques – spray pyrolysis - laser ablation

Textbooks

1. Materials Science and Engineering – An Introduction, William D Callister, 12th Edition, John Wiley
2. Nanomaterials – An introduction to synthesis, properties and applications, D. Vollath, Wiley-VCH, Second Edition 2013.

Reference Books

Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
2. Nanoscale materials -Liz Marzan and Kamat.
3. Physical properties of Carbon Nanotube-R Satio.
4. Polymer nanocomposites: Edited by Yiu-Wing Mai and Zhong-Zhen Yu, First published 2006, Woodhead Publishing Limited and CRC Press LLC, USA.
5. Physics of Magnetism - S. Chikazumi and S.H. Charap.
6. Magnetostriction and Magnetomechanical Effects - E.W. Lee.
7. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell

Open Educational Resources (OER)

- **https://youtu.be/6TprsnrvKIk**
- **https://youtu.be/j_wQgy97Pi4**
- **https://youtu.be/CJn2gXp3pyo**
- **https://youtu.be/TgwpVGWL6dQ**
- **https://youtu.be/nSAvyQajVzE**
- **https://youtu.be/mbOQYlBp0VQ**
- **https://youtu.be/ev1EiLWgDIs**

Assessment & Evaluation

Components	Assignment	Mid Term	Attendance	End Term
Weightage (%)	**20**	**20**	**10**	**50**

ProgrammeAnd Course Mapping

Course Code and Title	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
Minor 3 Nanostructured materials	**CO1**	3	3	-	-	-	-	-	-	-	-	3	3	-	-
	CO2	2	2	2	-	-	-	-	-	-	-	3	2	3	-
	CO3	-	-	-	2	-	2	2	-	-	-	-	2	3	-
	CO4	1	1	-	-	2	1	1	2	-	-	-	2	2	1

1=weakly mapped

2= moderately mapped
3=strongly mapped

RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

Unit i	Nano Composites and their Applications
Local	Advancing regional capabilities in nanocomposite research and applications.
Regional	Contributing to national research and development in nanocomposites for energy and technology sectors.
National	Sharing knowledge of advanced nanocomposites for global energy and technology advancements.
Global	Equipping students with knowledge of nanocomposites relevant to emerging industries.
Employability	Fostering innovation in nanocomposite-related startups for niche applications.
Entrepreneurship	Developing skills in nanocomposite design, fabrication, and characterization.
Skill development	Encouraging ethical conduct in nanocomposite research and application

	development.
Professional ethics	Exploring the potential impact of nanocomposites, nanoceramics, and nanopolymers on gender-related issues.
Gender	Considering ethical and societal values in the development of nanocomposites.
Human values	Exploring sustainable applications of nanocomposites for environmental conservation.
Environment & sustainability	Exploring sustainable nanomaterials and their applications.
Unit ii	Nano ceramics
Local	Strengthening regional expertise in nanoceramics and nanopolymer development.
Regional	Enhancing national capabilities in nanoceramics, nanopolymer, and conducting polymer research.
National	Contributing to global research in nanoceramics, nanopolymer, and conducting polymer fields.
Global	Developing students' skills in nanoceramics, nanopolymer synthesis, and characterization.
Employability	Encouraging entrepreneurship in nanoceramics, nanopolymer, and conducting polymer sectors.
Entrepreneurship	Enhancing skills in nanoceramics, nanopolymer synthesis, and application development.
Skill development	Promoting ethical research and innovation in nanoceramics, nanopolymer, and conducting polymer fields.
Professional ethics	Investigating gender-inclusive approaches to nanotechnology applications and research.
Gender	Incorporating human values into nanoceramics, nanopolymer, and conducting polymer research.
Human values	Investigating environmentally friendly approaches in nanoceramics, nanopolymer, and conducting polymer development.
Environment & sustainability	Exploring quantum solutions for environmental challenges.
Unit iii	Classification of conducting polymers
Local	Promoting regional innovation in conducting polymer applications.
Regional	Advancing national research in conducting polymers for critical areas like energy devices.
National	Advancing global understanding of conducting polymers and their applications.
Global	Enhancing students' employability with expertise in conducting polymers for various sectors.
Employability	Supporting entrepreneurship in conducting polymer applications such as electronic devices.

Entrepreneurship	Developing expertise in conducting polymer synthesis and applications.
Skill development	Emphasizing ethical considerations in conducting polymer applications for safety and reliability.
Professional ethics	Addressing gender inclusivity in conducting polymer research and its applications.
Gender	Integrating human values into conducting polymer applications for societal benefit.
Human values	Promoting sustainable conducting polymer applications that align with environmental goals.
Environment & sustainability	Investigating sustainable nanomaterials and processes.
Unit iv	Miscellaneous applications of nanotechnology
Local	Investigating miscellaneous nanotechnology applications with local relevance, e.g., dental implants.
Regional	Supporting regional industries with diverse nanotechnology applications.
National	Promoting the adoption of nanotechnology in various national sectors through diverse applications.
Global	Exploring global applications of nanotechnology in areas like tissue engineering and biopolymer tagging.
Employability	Preparing students for careers in diverse nanotechnology applications globally.
Entrepreneurship	Promoting entrepreneurship in miscellaneous nanotechnology applications like semiconductor quantum dots.
Skill development	Developing skills in various thin film formation methods, both physical and chemical.
Professional ethics	Ensuring ethical practices in miscellaneous nanotechnology applications, especially in healthcare-related fields.
Gender	Considering gender perspectives in the development and application of miscellaneous nanotechnology products.
Human values	Reflecting human values in miscellaneous nanotechnology applications, especially those with healthcare implications.
Environment & sustainability	Ensuring the environmental sustainability of miscellaneous nanotechnology applications, such as biopolymer tagging.
SDG	Quality education (4), decent work and economic growth (8), industry, innovation and infrastructure (9)
Nep 2020	Towards a more holistic and multidisciplinary education Promoting high-quality research
Poe/4th IR	Preparing students for the Fourth Industrial Revolution.

Teaching Plan:

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/Reference Book [RB]-Chapter/Page No./OER	Teaching-Learning Method
1	Unit I: Nano Composites and Applications	TB - Materials Science and Engineering, Ch. 1-2	Lecture and Discussion
2	Unit I: Metal-Metal Nano composites	TB - Materials Science and Engineering, Ch. 4	Lecture and Discussion
3	Unit I: Magnetic Nano composites	RB - Nanoscale materials, Ch. 5	Lecture and Discussion
4	Unit I: Ceramic Nano composites	RB - Nanoscale materials, Ch. 6	Lecture and Discussion
5	Unit I: Quantum confinement in nanostructures	TB - Materials Science and Engineering, Ch. 11	Lecture and Discussion
6	Unit II: Nano ceramics	TB - Nanomaterials, Ch. 8	Lecture and Discussion
7	Unit II: Nano polymers	TB - Nanomaterials, Ch. 9	Lecture and Discussion
8	Unit III: Conducting polymers	RB - Polymer nanocomposites, Ch. 7	Lecture and Discussion
9	Unit III: Applications of conducting polymers	RB - Polymer nanocomposites, Ch. 8	Lecture and Discussion
10	Unit IV: Miscellaneous nanotechnology applications	RB - Carbon Nanotubes, Ch. 3	Lecture and Discussion
11	Unit IV: Thin Film Formation - Physical methods	TB - Materials Science and Engineering, Ch. 17	Lecture and Practical Demonstration
12	Unit IV: Thin Film Formation - Chemical methods	TB - Materials Science and Engineering, Ch. 18	Lecture and Practical Demonstration
13	Unit IV: Thin Film Formation - Chemical methods	RB - Polymer nanocomposites, Ch. 10	Lecture and Practical Demonstration
14	Unit IV: Thin Film Formation - Chemical methods	RB - Nanoscale materials, Ch. 9	Lecture and Practical Demonstration
15	Unit IV: Thin Film Formation - Chemical methods	OER (Links provided)	Video Lectures
16	Revision and Recap	-	Review and Discussion

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Understand the fundamentals of nanomaterials and nano composites, including their classifications, properties, and various applications in fields such as nuclear energy, spintronics, high-temperature environments, catalysis, and consumer products.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Analyze the principles of quantum confinement in semiconductor nanostructures and explain how size effects influence the properties of nanostructures in three-dimensional (3D), two-dimensional (2D), one-dimensional (1D), and zero-dimensional (0D) structures.		
3	Evaluate the synthesis and characteristics of different nano materials, such as nano ceramics, nano polymers, and conducting polymers, and their application potential in fields such as dielectrics, ferroelectrics, magneto ceramics, sensors, electronic devices, and electrochemical energy devices.		
4	Demonstrate knowledge and understanding of thin film formation methods, including physical methods like thermal evaporation, sputtering, and epitaxy, as well as chemical methods like chemical vapor deposition and chemical solution deposition, and apply this		

	knowledge in real-world scenarios.		

UNS104	Crystallography	L	T	P	C
Version 1.0		4	0	0	4
Total Contact Hours	60				
Pre-requisites/Exposure	Solid State Physics				
Co-requisites	Basic knowledge in Materials Science				

Course Description

This course is an introduction to the principles of structure of materials, and theory and applications of diffraction and imaging techniques for materials characterization using X-ray diffraction and transmission electron microscopy (TEM).

Course Outcomes

CO1: Analyze and interpret the key principles of geometric crystallography, including the properties of crystalline matter, the application of symmetry operations, and understanding of crystallographic notations.

CO2: Compare and contrast various crystal structures, apply principles that govern the formation of these structures, and utilize X-ray diffraction methods to investigate structural variations.

CO3: Investigate and articulate the relationship between the physical properties of crystals and their crystalline symmetry, demonstrating an understanding of optical properties and how they're observed and determined.

CO4: Evaluate the impact of crystal defects and dynamics on the physical properties of crystals, and develop a comprehensive understanding of crystal formation, growth, and real crystal morphology.

Course Content

Unit 1. 15 Lectures

Geometric crystallography: Historical development of Crystallography, The periodic table of the elements and interatomic bonds, Order and periodicity. Properties of crystalline matter, Crystal networks. Periodic two-dimensional networks.Bravais networks and crystalline systems. Elements of the periodic networks, Crystallographic notations: knots rows and planes. Weiss parameters and Miller indices, Relationship between morphology and structure, Crystallographic areas, Symmetry operations in 2 and 3 dimensions, The 32 specific groups. Crystal systems and symmetry, Crystal morphology.

Unit 2. 15 Lectures

Structural crystallography and crystal chemistry : The symmetry of the unit cell., Space groups, Atomic positions and structural positions, Crystal structures, Principles that govern the formation of crystalline structures, Variations in the chemical composition of the crystals. Isomorphism, solid solutions and stoichiometry, X-ray diffraction by crystals.Difraction methods: fundamentals and information they provide.

Unit 3. 15 Lectures

Physical properties of crystals: Introduction to the physical properties of crystals, and their relation to crystalline symmetry. Optical properties, Nature of light, and other basic concepts, Optical properties,Isotropy and optical anisotropy. The optical surfaces. , Optical properties, The transmitted light polarization microscope, Optical properties, Optical observations with parallel light and without analyzer. Optical determinations with parallel light and analyzer.Optical determinations with convergent light.

Unit 4. 15 Lectures

Crystal Dynamics : The real crystal. Crystal defects and crystalline dynamics. Influence of defects on the physical properties of crystals, Crystal defects: punctual, linear, two-dimensional and three-dimensional. Crystal formation and growth.Morphology of the real crystal. Add and twins. Polymorphism

Textbook: David B. Williams and C. Barry Carter, *Transmission Electron Microscopy: A Textbook for Materials Science,* Plenum Press, NY (2007). (Required)

Reference Books

Introduction to Solid State Physics - C. Kittel
Principles of Solid State Physics - R. A. Levy Solid State Physics- S.O. Pillai
Elements of X-Ray diffraction - B.D. Cullity
Elementary Solid State Physics - Ali Omar
Elements of Solid State Physics - J.P. Srivastava

Nano; The Essentials By T. Pradeep (Tata McGraw Hill Publ)

Open Education Resources

- Introduction to Crystallography and Mineral Crystal Systems - A comprehensive overview of geometric crystallography.
- Crystallography Open Database - A database of crystal structures.
- MIT OpenCourseWare - Crystal Structure Reading Collection - Reading materials on crystal structures.
- Fundamentals of Crystallography - An article on the principles that govern the formation of crystalline structures.
- Introduction to Crystal Physics - A detailed course on the physical properties of crystals.
- Crystalline Materials - Explains the optical properties of crystals.
- Solid State Physics - A chapter on crystal defects and dynamics from a course on solid state physics.
- Crystal Growth & Design - A journal with open access articles on crystal formation and growth.

Assessment & Evaluation

Components	**Assignment**	**Mid Term**	**Attendance**	**End Term**
Weightage (%)	**20**	**20**	**10**	**50**

Programme and Course Mapping

Course Code & Title	**Course Outcomes (CO)**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
UNS104	CO1	3	2	1	3	1	2	3	3	1	1	3	3	1	2
Crystallography	CO2	3	2	1	3	2	3	2	3	1	1	3	3	2	2
	CO3	3	3	2	2	2	3	2	3	1	1	3	2	3	3

	CO4	3	3	2	3	3	3	2	3	1	1	3	3	3	3

RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

Unit 1: Geometric Crystallography

Indicator	Relevant Course Content
Local	Symmetry operations in 2 and 3 dimensions, Crystal morphology
Regional	-
National	Historical development of Crystallography, Properties of crystalline matter, Crystal networks, Crystallographic notations: knots rows and planes, Symmetry operations in 2 and 3 dimensions, The 32 specific groups, The symmetry of the unit cell, Atomic positions and structural positions
Global	Historical development of Crystallography, Properties of crystalline matter, Crystal networks, Crystallographic notations: knots rows and planes, Symmetry operations in 2 and 3 dimensions, The 32 specific groups, The symmetry of the unit cell, Atomic positions and structural positions
Employability	Symmetry operations in 2 and 3 dimensions, Crystal morphology
Entrepreneurship	-
Skill Development	Symmetry operations in 2 and 3 dimensions, Crystal morphology
Professional Ethics	Symmetry operations in 2 and 3 dimensions, Crystal morphology
Gender	-
Human Values	Symmetry operations in 2 and 3 dimensions, Crystal morphology
Environment & Sustainability	Symmetry operations in 2 and 3 dimensions, Crystal morphology
SDG	-
Nep 2020	-
Poe/4th IR	-

Unit 2: Structural Crystallography and Crystal Chemistry

Indicator	Relevant Course Content
Local	The symmetry of the unit cell, Variations in the chemical composition of the crystals, X-ray diffraction by crystals, Diffraction methods: fundamentals and information they provide
Regional	-

National	The symmetry of the unit cell, Variations in the chemical composition of the crystals, Isomorphism, solid solutions, and stoichiometry, X-ray diffraction by crystals,
Global	The symmetry of the unit cell, solid solutions, and stoichiometry, X-ray diffraction by crystals, Diffraction methods: fundamentals and information they provide, Crystal defects: punctual, linear, two-dimensional, and three-dimensional, The real crystal, Influence of defects on the physical properties of crystals
Employability	The real crystal
Entrepreneurship	-
Skill Development	The real crystal
Professional Ethics	The real crystal
Gender	-
Human Values	The real crystal
Environment & Sustainability	The real crystal
SDG	-
Nep 2020	-
Poe/4th IR	-

Unit 3: Physical Properties of Crystals

Indicator	Relevant Course Content
Local	-
Regional	-
National	Introduction to the physical properties of crystals, and their relation to crystalline symmetry, Optical properties, Nature of light, and other basic concepts, Optical properties, Isotropy and optical anisotropy, The optical surfaces, Optical properties, The transmitted light polarization microscope, Optical properties, Optical observations with parallel light and without analyzer, Optical determinations with parallel light and analyzer, Optical determinations with convergent light
Global	Introduction to the physical properties of crystals, and their relation to crystalline symmetry, Optical properties, Nature of light, and other basic concepts, Optical properties, Isotropy and optical anisotropy, The optical surfaces, Optical properties, The transmitted light polarization microscope, Optical properties, Optical observations with parallel light and without analyzer, Optical determinations with parallel light and analyzer, Optical determinations with convergent light
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-

Gender	-
Human Values	-
Environment & Sustainability	-
SDG	-
Nep 2020	-
Poe/4th IR	-

Unit 4: Crystal Dynamics

Indicator	Relevant Course Content
Local	-
Regional	-
National	The real crystal, Crystal defects: punctual, linear, two-dimensional, and three-dimensional, Influence of defects on the physical properties of crystals, Crystal formation and growth, Morphology of the real crystal, Add and twins, Polymorphism
Global	The real crystal, Crystal defects: punctual, linear, two-dimensional, and three-dimensional, Influence of defects on the physical properties of crystals, Crystal formation and growth, Morphology of the real crystal, Add and twins, Polymorphism
Employability	The real crystal
Entrepreneurship	-
Skill Development	The real crystal
Professional Ethics	The real crystal
Gender	-
Human Values	The real crystal
Environment & Sustainability	The real crystal
SDG	-
Nep 2020	-
Poe/4th IR	-

Teaching Plan:

Week	Topics	Reference Books/Open Education Resources	Teaching Learning Method
Week 1	Introduction and Historical Development of Crystallography	C. Kittel, Introduction to Solid State Physics, Webmineral: Crystallography	Lectures
Week 2	The Periodic Table of the	David B. Williams and C. Barry Carter,	Lectures and Group

	Elements and Interatomic Bonds	Transmission Electron Microscopy: A Textbook for Materials Science	Discussions
Week 3	Order and Periodicity, Properties of Crystalline Matter	R. A. Levy, Principles of Solid State Physics, MIT OpenCourseWare: Solid State Physics	Lectures and Demonstrations
Week 4	Crystal Networks, Periodic Two-Dimensional Networks	S.O. Pillai, Solid State Physics, MIT OpenCourseWare: Crystal Structures	Lectures and Practical Lab Sessions
Week 5	Bravais Networks and Crystalline Systems	B.D. Cullity, Elements of X-Ray Diffraction, Crystallography Open Database	Lectures and Group Discussions
Week 6	Elements of the Periodic Networks, Crystallographic Notations	Ali Omar, Elementary Solid State Physics, Crystallography and Minerals Arranged by Crystal Form	Lectures and Demonstrations
Week 7	Crystallographic notations: knots rows and planes. Weiss parameters and Miller indices, Relationship between morphology and structure, Crystallogra	Transmission Electron Microscopy: A Textbook for Materials Science Fundamentals of Crystallography - An article on the principles that govern the formation of crystalline structures.	Review Sessions and Examinations
Week 8	Symmetry Operations in 2 and 3 Dimensions, The 32 Specific Groups	J.P. Srivastava, Elements of Solid State Physics, Crystallography in Real Life	Lectures and Group Discussions
Week 9	Crystal Systems and Symmetry, Crystal Morphology	T. Pradeep, Nano; The Essentials, Crystallography Matters!	Lectures and Demonstrations
Week 10	The Symmetry of the Unit Cell, Space Groups	C. Kittel, Introduction to Solid State Physics, Lecture on Crystallography	Lectures and Practical Lab Sessions
Week 11	Atomic Positions and Structural Positions, Crystal Structures	R. A. Levy, Principles of Solid State Physics, Structural Crystallography: An Introduction	Lectures and Demonstrations
Week 12	Introduction to the Physical Properties of Crystals and their Relation to Crystalline Symmetry	S.O. Pillai, Solid State Physics, The Physics of Crystals	Lectures and Group Discussions
Week 13	The Real Crystal, Crystal Defects and Crystalline Dynamics	David B. Williams and C. Barry Carter, Transmission Electron Microscopy: A Textbook for Materials Science, Crystalline Materials	Lectures and Practical Lab Sessions

Week 14	Crystal formation and growth. Morphology of the real crystal.	David B. Williams and C. Barry Carter, Transmission Electron Microscopy: A Textbook for Materials Science, Crystalline Materials	Lectures

Facilitating the Achievement of Course Learning Outcomes

Unit	Course Learning Outcomes (CLO)	Teaching Learning Activity (TLA)	Assessment Task Methods (ATM)
Unit 1	Analyze and interpret the key principles of geometric crystallography, including the properties of crystalline matter, the application of symmetry operations, and understanding of crystallographic notations.	Lectures and demonstrations, self-study, guided group discussion.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
Unit 2	Compare and contrast various crystal structures, apply principles that govern the formation of these structures, and utilize X-ray diffraction methods to investigate structural variations.	Practical lab sessions, problem-solving sessions, guided reading.	
Unit 3	Investigate and articulate the relationship between the physical properties of crystals and their crystalline symmetry, demonstrating an understanding of optical properties and how they're observed and determined.	Demonstrations of physical properties of crystals, group discussions on optical properties, practical sessions on observation techniques.	
Unit 4	Evaluate the impact of crystal defects and dynamics on the physical properties of crystals, and develop a comprehensive understanding of crystal formation, growth, and real crystal morphology.	Case study analysis, collaborative group work on specific topics, self-study on crystal defects.	

UNS105	Crystallography lab	L	T	P	C
Version 1.0		0	0	2	1
Total Contact Hours	30				
Pre-requisites/Exposure	Solid State Physics				
Co-requisites	Basic knowledge in Materials Science				

Course Description

This course is an introduction to study of structure of materials, coordination number, bond lengths etc using Diamond software

Course Outcomes

CO1: Describe the theoretical foundations of crystallography.
CO2: Understand the properties and symmetry of crystals.
CO3: Analyze the bonding between atoms.
CO4: Evaluation of the Coordination number

Course Content

List of experiments

1. To Study the structure of Simple cubic crystal system.
2. To Study the structure of Body centered cubic crystal system
3. To Study the structure of Face centered cubic crystal system
4. To Study the structure of tetragonal crystal system
5. To Study the structure of Orthorhombic crystal system
6. To Study the structure of Rhombohedral crystal system
7. To Study the structure of Hexagonal crystal system
8. To Study the structure of monoclinic Crystal system
9. To Study the structure of Triclinic crystal system
10. To Study the structure of Perovskites.

Reference Books

- Introduction to Solid State Physics - C. Kittel
- Principles of Solid State Physics - R. A. Levy
- Solid State Physics- S.O. Pillai
- Elements of X-Ray diffraction - B.D. Cullity
- Elementary Solid State Physics - Ali Omar

- Elements of Solid State Physics - J.P. Srivastava
- Nano; The Essentials By T. Pradeep (Tata McGraw Hill Publ)

Open Educational Resources (OER)

- https://youtu.be/HCWwRh5CXYU
- https://youtu.be/_9RnbGqtkd4
- https://youtu.be/GSPVC34ijIA
- https://youtu.be/JS9ysbgr0BE
- https://youtu.be/07iZ7-IEyYE

Assessment & Evaluation

Components	Conduct of Experiment	Lab Record/Viva Voce	Attendance	End Term Examination
Weightage (%)	**20**	**20**	**10**	**50**

Programme and Course Mapping

Course Code & Title	Course Outcomes (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
UNS105 Crystallography	CO1	3	2	1	2	1	3	2	3	3	2	3	3	3	2
	CO2	3	3	2	2	1	2	2	3	3	2	3	3	3	2
	CO3	3	2	1	3	2	3	2	3	3	2	3	2	3	2
	CO4	2	1	1	3	2	3	2	3	3	2	2	3	2	3

RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

Indicator	Relevant Course Content
Local	To Study the structure of Simple cubic crystal system, To Study the structure of Body centered cubic crystal system, To Study the structure of Face centered cubic crystal system, To Study the structure of tetragonal crystal system, To Study the structure of Orthorhombic crystal system, To Study the structure of Rhombohedral crystal system, To Study the structure of Hexagonal crystal system, To Study the structure of monoclinic Crystal system, To Study the structure of

	Triclinic crystal system, To Study the structure of Perovskites
Regional	-
National	To Study the structure of Simple cubic crystal system, To Study the structure of Body centered cubic crystal system, To Study the structure of Face centered cubic crystal system, To Study the structure of tetragonal crystal system, To Study the structure of Orthorhombic crystal system, To Study the structure of Rhombohedral crystal system, To Study the structure of Hexagonal crystal system, To Study the structure of monoclinic Crystal system, To Study the structure of Triclinic crystal system, To Study the structure of Perovskites
Global	To Study the structure of Simple cubic crystal system, To Study the structure of Body centered cubic crystal system, To Study the structure of Face centered cubic crystal system, To Study the structure of tetragonal crystal system, To Study the structure of Orthorhombic crystal system, To Study the structure of Rhombohedral crystal system, To Study the structure of Hexagonal crystal system, To Study the structure of monoclinic Crystal system, To Study the structure of Triclinic crystal system, To Study the structure of Perovskites
Employability	-
Entrepreneurship	-
Skill Development	-
Professional Ethics	-
Gender	-
Human Values	-
Environment & Sustainability	-
SDG	-
Nep 2020	-
Poe/4th IR	-

Teaching Plan:

Week	Topic/Unit No.	Textbook/Reference	Teaching-Learning Method

1	Introduction to Crystal Systems	TB - Introduction to Solid State Physics - C. Kittel, Ch. 1, OER1	Lecture, Demonstration
2	Simple Cubic Crystal System	TB - Introduction to Solid State Physics - C. Kittel, Ch. 3, OER1	Practical Lab Session
3	Body Centered Cubic Crystal System	TB - Introduction to Solid State Physics - C. Kittel, Ch. 3, OER2	Lecture, Discussion
4	Face Centered Cubic Crystal System	TB - Introduction to Solid State Physics - C. Kittel, Ch. 3, OER 3	Practical Lab Session
5	Tetragonal Crystal System	TB - Introduction to Solid State Physics - C. Kittel, Ch. 4, OER4	Lecture, Demonstration
6	Orthorhombic Crystal System	TB - Introduction to Solid State Physics - C. Kittel, Ch. 4, OER 4	Practical Lab Session
7	Rhombohedral Crystal System	TB - Introduction to Solid State Physics - C. Kittel, Ch. 4, OER 4	Lecture, Discussion
8	Hexagonal Crystal System	TB - Introduction to Solid State Physics - C. Kittel, Ch. 5, OER 4	Practical Lab Session
9	Monoclinic Crystal System	TB - Introduction to Solid State Physics - C. Kittel, Ch. 5, OER 4	Lecture, Demonstration
10	Triclinic Crystal System	TB - Introduction to Solid State Physics - C. Kittel, Ch. 5, OER 4	Practical Lab Session
11	Perovskites Structure	RB - Nano; The Essentials By T. Pradeep, Relevant Chapters, OER 4	Lecture, Discussion
12	X-Ray Diffraction	TB - Elements of X-Ray diffraction - B.D. Cullity, Relevant Chapters, OER 5	Discussion
13	Solid State Physics Principles	RB - Principles of Solid State Physics - R. A. Levy, Relevant Chapters	Lecture, Demonstration
14	Review and Applications	TB - Solid State Physics- S.O. Pillai, Relevant Chapters	Practical Lab Session

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Understand the fundamental principles and characteristics of various crystal systems in solid	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii)	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term

	state physics.	Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Demonstrate proficiency in identifying and describing the structural arrangements of different crystal systems.		
3	Apply theoretical knowledge to analyze and differentiate crystal structures in practical laboratory experiments.		
4	Gain insights into the unique properties and applications of specific crystal systems, such as perovskites, in various scientific and technological contexts.		

UNS106	SYNTHESIS OF NANOMATERIALS-I	L	T	P	C
Version 1.0		4	0	0	4
Total Contact Hours	60				
Pre-requisites/Exposure					
Co-requisites					

Course outcomes

CO1: Describe the fundamental concepts and methods involved in nanotechnology, including top-down and bottom-up processes, the properties of atoms and solids, and the different classification of nanostructures.

CO2: Apply principles of nanotechnology to understand the synthesis and growth of nanoparticles through both homogeneous and heterogeneous nucleation.

CO3: Analyze various fabrication methods and their impact on the properties of nanoparticles and nanostructures.
CO4: Evaluate the effectiveness of various methods for creating one-dimensional nanostructures, such as nanowires and nanorods.

UNIT- I 15 contact hours

Generic methodologies for nanotechnology: classification and fabrication

Introduction and classification: definition nanotechnology, Classification of nanostructures, Nanoscale architecture, Summary of the electronic properties of atoms and solids: The isolated atom Bonding between atoms, Giant molecular solids, The free electron model and energy bands, Crystalline solids, Periodicity of crystal lattices, Electronic conduction; Effects of the nanometer length scale: Changes to the system total energy, Changes to the system structure, How nanoscale dimensions affect properties, Fabrication methods: Top-down processes, Bottom-up processes, Methods for templating the growth of nanomaterials, Ordering of nanosystems, Preparation, safety and storage issues.

UNIT-II 15 contact hours

Physical Chemistry of Solid Surfaces

Introduction, Surface Energy, Chemical Potential as a Function of Surface Curvature, Electrostatic Stabilization: Surface charge density, Electric potential at the proximity of solid surface, Van der Waals attraction potential, Interactions between two particles: DLVO theory, Solvent and polymer, Interactions between polymer layers, Mixed steric and electric interactions.

UNIT-III 15 contact hours

Zero-Dimensional Nanostructures: Nanoparticles

Introduction, Nanoparticles through Homogeneous Nucleation:Fundamentals of homogeneous nucleation, Subsequent growth of nuclei (Growth controlled by diffusion, Growth controlled by surface process), Synthesis of metallic nanoparticles(Influences of reduction reagents, Influences by other factors, Influences of polymer stabilizer), Synthesis of semiconductor nanoparticles, Synthesis of oxide nanoparticles (Introduction to sol-gel processing, Forced hydrolysis, Controlled release of ions),Vapor phase reactions, Solid state phase segregation;

Nanoparticles through Heterogeneous Nucleation:(Fundamentals of heterogeneous nucleation, Synthesis of nanoparticles); Kinetically Confined Synthesis of Nanoparticles:(Synthesis inside micelles or using microemulsions, Aerosol synthesis, Growth termination, Spray pyrolysis, Template-based synthesis);Epitaxial Core-Shell Nanoparticles.

UNIT IV15 contact hours

One-Dimensional Nanostructures: Nanowires and Nanorods

Introduction, Spontaneous Growth: Evaporation (dissolution)-condensation growth:(Fundamentals of evaporation (dissolution)-condensation growth, Evaporation-condensation growth, Dissolution-condensation growth);

Vapor (or solution)-liquid-solid (VLS or SLS) growth:(Fundamental aspects of VLS and SLS growth, VLS growth of various nanowires, Control of the size of nanowires, Precursors and catalysts, SLS growth);

Stress-induced recrystallization: Template-Based Synthesis: Electrochemical deposition, Electrophoretic deposition, Template filling (Colloidal dispersion filling, Melt and solution filling, Chemical vapor deposition, Deposition by centrifugation), Converting through chemical reactions; Electrospinning; Lithography.

Textbooks:

1. "Introduction to Nanoscience and Nanotechnology" by Gabor L. Hornyak, H.F. Tibbals, JoydeepDutta, John J. Moore
2. "Nanoscale Science and Technology" by Robert Kelsall, Ian Hamley, Mark Geoghegan

Reference Books:

1. "Nanochemistry: A Chemical Approach to Nanomaterials" by Geoffrey A. Ozin, Andre Arsenault
2. "Nanotechnology: An Introduction" by Jeremy Ramsden
3. "The Physics of Nanoelectronics: Transport and Fluctuation Phenomena at Low Temperatures" by Tero T. Heikkila
4. "Nanoscale: Visualizing an Invisible World" by Kenneth S. Deffeyes, Stephen E. Deffeyes
5. "Nanotechnology: Principles and Practices" by Sulabha K. Kulkarni

Open Educational Resources (OER)

- https://byjus.com/jee/surface-chemistry/
- https://onlinecourses.nptel.ac.in/noc21_cy45/preview
- https://www.youtube.com/watch?v=O2So0xcdDiA
- https://www.nobelprize.org/prizes/chemistry/2007/ertl/lecture/

- https://www.doubtnut.com/question-answer-chemistry/if-physical-adsorption-the-gas-molecules-are-held-on-solid-surface-by-46827508

Assessment & Evaluation

Components	Assignment	Mid Term	Attendance	End Term
Weightage (%)	20	20	10	50

ProgrammeAnd Course Mapping

Course Code	Course	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO7	PO 8	PO 9	PO1 0	PSO 1	PSO 2	PSO 3	PS O4
UNS106 SYNTHESIS OF NANOMATERIALS-I	CO 1	3	2	3	2	3	2	2	1	1	1	3	3	2	2
	CO 2	3	3	2	2	2	3	3	2	1	1	3	2	3	3
	CO 3	3	3	2	3	3	3	3	2	1	1	3	3	3	3
	CO 4	3	3	3	3	3	3	3	2	1	1	3	3	3	3

Key: 1=Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

Unit i	Generic methodologies for nanotechnology: classification and fabrication
Local	Understanding basic concepts of nanotechnology at community colleges or local industries.
Regional	Sharing and collaboration among regional research institutes.
National	Establishing national standards & guidelines for nanotech.
Global	Collaborative international research & global standards for nanotech.
Employability	Creation of jobs in nanotech research & development.

Entrepreneurship	Start-ups offering nano-fabrication services.
Skill development	Training in nano-fabrication techniques.
Professional ethics	Responsible nanotech development & research practices.
Gender	Promote gender equality in nanotech research roles.
Human values	Ensuring nanotech is used for the betterment of society.
Environment & sustainability	Adopting sustainable nanotech fabrication practices.
Unit ii	Physical Chemistry of Solid Surfaces
Local	Enhancing knowledge of solid surfaces in local industries.
Regional	Regional workshops on surface chemistry.
National	National policies on solid surface treatments & applications.
Global	International collaborations on advanced surface chemistry research.
Employability	Jobs in surface analysis, research, and application development.
Entrepreneurship	Businesses offering specialized surface treatments & analytics.
Skill development	Skill development in surface analysis techniques.
Professional ethics	Ensuring ethical practices in surface treatment & analysis.
Gender	Encourage more female scientists in surface chemistry research.
Human values	Consideration of human values in the application of surface treatments.
Environment & sustainability	Environmentally friendly surface treatments and practices.
Unit iii	Zero-Dimensional Nanostructures: Nanoparticles

Local	Promotion of local manufacturing & research in nanoparticles.
Regional	Regional collaborations for nanoparticle manufacturing & research.
National	Development of national manufacturing hubs for nanoparticles.
Global	Sharing and collaboration on nanoparticle synthesis at an international level.
Employability	Employment opportunities in nanoparticle manufacturing industries.
Entrepreneurship	Start-ups focusing on the production and sale of nanoparticles for various applications.
Skill development	Training programs on nanoparticle synthesis methods.
Professional ethics	Adhering to ethical standards in nanoparticle production.
Gender	Promoting gender inclusivity in nanoparticle research and development.
Human values	Using nanoparticles for applications that benefit society at large.
Environment & sustainability	Sustainable methods of nanoparticle synthesis and minimizing environmental impacts.
Unit iv	One-Dimensional Nanostructures: Nanowires and Nanorods
Local	Local manufacturing & research in nanowires and nanorods.
Regional	Regional advancements in nanowire and nanorod production techniques.
National	National advancements in one-dimensional nanostructures for various applications.
Global	Global research partnerships in the field of nanowires and nanorods.
Employability	Employment in industries focusing on nanowires and nanorods.
Entrepreneurship	Entrepreneurial ventures into nanowire &nanorod production and

	applications.
Skill development	Workshops on the fabrication of nanowires and nanorods.
Professional ethics	Maintaining ethical standards in the manufacturing of nanowires and nanorods.
Gender	Gender equality in roles related to research and development of nanowires and nanorods.
Human values	Manufacturing nanowires &nanorods keeping human needs and values in mind.
Environment & sustainability	Emphasis on green and sustainable practices in the production of nanowires and nanorods.
SDG	Goal 9: Industry, Innovation, and Infrastructure, Goal 12: Responsible Consumption and Production Goal 6: Clean Water and Sanitation, Goal 14: Life Below Water , Goal 3: Good Health and Well-being, Goal 7: Affordable and Clean Energy, Goal 11: Sustainable Cities and Communities
Nep 2020	Multidisciplinary Education Emphasis on Research and Innovation, Integrating Technology in Education, Focus on Experiential Learning, Emphasis on Practical Knowledge, Critical Thinking and Creativity
Poe/4th IR	Advanced Materials, Nanotechnology

Teaching Plan:

Week	**Topics**	**Reference Books/Open Education Resources**	**Teaching Learning Method**
1	Introduction to nanotechnology, classification of nanostructures	"Introduction to Nanotechnology" by Charles P. Poole Jr. and Frank J. , https://byjus.com/jee/surface-chemistry/ Owens	Lecture, Group Discussion

2	Nanoscale architecture, electronic properties of atoms and solids	"Nanostructures and Nanotechnology" by Douglas Natelson, https://onlinecourses.nptel.ac.in/noc21_cy45/preview	Lecture, Group Discussion
3	The free electron model and energy bands, crystalline solids, periodicity of crystal lattices	"Nanostructures and Nanotechnology" by Douglas Natelson, https://www.youtube.com/watch?v=O2So0xcdDiA	Lecture, Group Discussion
4	Electronic conduction, effects of the nanometre length scale	"Nanostructures and Nanotechnology" by Douglas Natelson, https://www.nobelprize.org/prizes/chemistry/2007/ertl/lecture/	Lecture, Group Discussion
5	Fabrication methods: Top-down processes, bottom-up processes	"Introduction to Nanotechnology" by Charles P. Poole Jr. and Frank J. Owens, https://www.doubtnut.com/question-answer-chemistry/if-physical-adsorption-the-gas-molecules-are-held-on-solid-surface-by-46827508	Lecture, Lab Session
6	Introduction to surface energy, chemical potential as a function of surface curvature	"Nano: The Essentials" by T. Pradeep, https://www.nobelprize.org/prizes/chemistry/2007/ertl/lecture/	Lecture, Lab Session
7	Electrostatic Stabilization: Surface charge density, electric potential at the proximity of solid surface, Van der Waals attraction potential	"Nano: The Essentials" by T. Pradeep,, https://www.youtube.com/watch?v=O2So0xcdDiA	Lecture, Lab Session
8	Introduction to nanoparticles through homogeneous nucleation, subsequent growth of nuclei	"Nano: The Essentials" by T. Pradeep, https://onlinecourses.nptel.ac.in/noc21_cy45/preview	Lecture, Lab Session
9	Synthesis of metallic nanoparticles, semiconductor nanoparticles, oxide nanoparticles	"Principles of Nanotechnology" by G. Ali Mansoori, https://www.doubtnut.com/question-answer-chemistry/if-physical-adsorption-the-gas-molecules-are-held-on-solid-surface-by-46827508	Lecture, Lab Session

10	Nanoparticles through Heterogeneous Nucleation, Kinetically Confined Synthesis of Nanoparticles	"Principles of Nanotechnology" by G. Ali Mansoori, https://www.nobelprize.org/prizes/chemistry/2007/ertl/lecture/	Lecture, Lab Session
11	Introduction to one-dimensional nanostructures, spontaneous growth, evaporation (dissolution)-condensation growth	"Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience" by Edward L. Wolf, https://www.youtube.com/watch?v=O2So0xcdDiA	Lecture, Lab Session
12	Vapor (or solution)-liquid-solid (VLS or SLS) growth, stress-induced recrystallization	"Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience" by Edward L. Wolf, https://www.doubtnut.com/question-answer-chemistry/if-physical-adsorption-the-gas-molecules-are-held-on-solid-surface-by-46827508	Lecture, Lab Session
13	Template-Based Synthesis: Electrochemical deposition, Electrophoretic deposition, Template filling	"Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience" by Edward L. Wolf, https://www.youtube.com/watch?v=O2So0xcdDiA	Lecture, Lab Session
14	Revision and assessment preparation	All reference books and resources	Group Discussion, Q&A

Facilitating the Achievement of Course Learning Outcomes

Unit	Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
I	Understand the principles of nanotechnology, classification and fabrication of nanostructures, the effects of nanoscale dimensions on properties, and fabrication methods.	Lectures, group discussions, and problem-solving sessions. Students will study theoretical concepts and work on practical problems related to the fabrication of nanostructures.	• Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. •

II	Gain knowledge about the physical chemistry of solid surfaces, including surface energy, chemical potential, electrostatic stabilization, and DLVO theory.	Lectures and lab experiments. Students will study theoretical concepts and apply them in laboratory experiments to better understand the physical chemistry of solid surfaces.	End-term examinations.
III	Understand the concepts of zero-dimensional nanostructures, including the synthesis and growth of nanoparticles through homogeneous and heterogeneous nucleation, and kinetically confined synthesis.	Lectures, lab experiments, and group projects. Students will study theoretical concepts, conduct experiments, and work on projects related to the synthesis and growth of nanoparticles.	
IV	Learn about one-dimensional nanostructures, the growth processes of nanowires and nanorods, stress-induced recrystallization, and template-based synthesis techniques.	Lectures, lab experiments, and problem-solving sessions. Students will study theoretical concepts and conduct experiments related to the growth processes of nanowires and nanorods.	

UNS107	**SYNTHESIS OF NANOMATERIALS-I Lab**	L	T	P	C
Version 1.0		0	0	2	1
Total Contact Hours	30				
Pre-requisites/Exposure					
Co-requisites					

Course Objectives:

1. Understand the fundamental principles of thin film growth and the various techniques used in the fabrication of two-dimensional nanostructures.
2. Explore the unique properties of special nanomaterials, such as carbon fullerenes, nanotubes, mesoporous structures, and organic-inorganic hybrids.

3. Familiarize students with the fabrication processes and characterization techniques used in creating nanostructures through physical techniques like lithography and nanomanipulation.
4. Gain insight into the diverse applications of nanomaterials, including molecular electronics, nanoelectronics, catalysis, photonic crystals, and biological applications.

Course Outcomes:

CO1 ts will be able to explain the principles of film growth and differentiate between ; deposition techniques, such as solid state reaction method, coprecipitation d, and sol-gel films.

CO2 ts will comprehend the properties and applications of magneticlnanomaterials.

CO3 ts will comprehend the properties and applications of dielectric nanomaterials.

CO4 ; will be able to identify and analyze real-world applications of nanomaterials in uch as molecular electronics, nanoelectronics, catalysis, and photonic devices.

CATALOG DESCRIPTION

This course introduces the fundamentals of nanostructures, including their synthesis, characterization, and applications. Topics covered include thin films, carbon nanotubes, mesoporous structures, and quantum devices. A background in physics, chemistry, or materials science is recommended. Upon completion of this course, students will be able to: Understand the basic principles of nanostructure synthesis and characterization, apply these principles to the design and fabrication of nanostructures.

Course Content

1, Stabilization of $BaTiO_3$ particles..

2. Preparation of silver wires.

3. Preparation of magnetite/PS composite,

4 Find the dielectric properties of multilayer composite material.

5. Prepare core-shell type nanoparticles..

6 Find the optical band gap of $BaTiO_3$ nanoparticles.

7. Study the effect of heating rate during calcination on the optical properties of $BaTiO_3$.

8. Find the X ray density of nanoparticles.

Suggested Text Books

1 Nanostructures and Nanomaterials: Synthesis, Properties andApplications, G, Cao, Imperial College Press (2003).

Advanced Readings:

1. Nanoscale Science and Technology , Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons Ltd (2005).
2. Nanomaterials and Nanochemistry, C. Brechignac, P. Houdy, M. Lahmani, Springer-Verlag Berlin Heidelberg (2007).
3 Introduction to Nanoscale Science and Technology, Massimiliano Di Ventra, StephaneEvoy and James R. Heflin, Jr., Kluwer Academic Publishers (2004)
4. Springer handbook of nanotechnology , Bharat Bhushan (ed.) Spinger-Verlag Berlin Heidelberg New York (2004),

Open Educational Resources (OER)

https://www.youtube.com/watch?v=DnozInAi1q0
https://pubs.acs.org/doi/10.1021/acs.inorgchem.8b00381
https://pubs.rsc.org/en/content/articlelanding/2018/nr/c8nr02242a
https://pubs.acs.org/doi/10.1021/acs.nanolett.0c01565
https://doi.org/10.1007/s13233-017-5065-1
https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=853840
https://onlinelibrary.wiley.com/doi/full/10.1002/advs.202102221
https://pubs.acs.org/doi/abs/10.1021/cr100449n
https://pubs.rsc.org/en/content/articlelanding/2015/cs/c5cs00343a
https://www.mdpi.com/2073-4360/14/21/4664

Assessment & Evaluation

Components	Conduct of	Lab Record/Viva	Attendance	End Term
Weightage (%)	20	20	10	50

ProgrammeAnd Course Mapping

Course Objectives (CO)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PSO 1	PSO 2	PSO 3	PSO4
CO1: Principles of film growth	2	2	1	1	1	1	1	1	1	1	2	1	1	1
CO2: Properties and applications	1	2	1	2	2	1	1	1	1	1	2	2	1	1
CO3: Practical skills in lithography	1	1	3	3	1	3	1	3	1	1	1	3	1	1
CO4: Identify real-world applications	1	2	1	3	1	1	1	1	1	1	1	3	1	1

(Note: The numbers 1, 2, and 3 represent "lightly mapped," "moderately mapped," and "strongly mapped," respectively. Higher numbers indicate a stronger mapping between the Course Objectives and the Program Outcomes/Program Specific Outcomes.)

RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

Unit	Course content
Local	Strengthening local materials and electronics sector with advanced nanotech methodologies.
Regional	Enhancing regional research and industries with material innovation, fostering tech-based development.
National	Contributing to national advancements in electronics, materials science, and research sectors.
Global	Aligning with global research trends, fostering international collaborations, and integrating into global electronics and materials markets.
Employability	Opening avenues in electronics, material science, R&D roles, and nano-technology industries.
Entrepreneurship	Empowering tech-driven startups in nanomaterial production, electronics, and advanced material applications.
Skill development	Imparting crucial skills in nanomaterial preparation, analysis, and research methodologies.
Professional ethics	Advocating for responsible research practices, ethical material sourcing, and safe laboratory protocols.
Gender	Encouraging inclusivity in the traditionally male-dominated fields of material science and research.
Human values	Emphasizing on the responsible use of knowledge for societal benefits and ethical considerations in research.
Environment & sustainability	Promoting green practices in material synthesis, emphasizing eco-friendly methodologies and waste reduction.

SDG	Aligning with goals like Industry, Innovation, Infrastructure (Goal 9), and Responsible Consumption and Production (Goal 12) for sustainable development.
Nep 2020	Reinforcing the emphasis on practical knowledge, critical thinking, and integration of tech in education as per India's National Education Policy.
Poe/4th IR	Preparing for the Fourth Industrial Revolution by equipping learners with skills in advanced materials, nanotechnology, and innovative research practices vital for the age of cyber-physical systems.

Teaching Plan

Weekly Teaching	**Topic/Unit No.**	**Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]**	**Teaching-Learning Method**
Week 1			Class test/presentation/Assignments/Quizzer/ Viva/Project
Week 2	Stabilization of BaTiO3 particles..	https://www.youtube.com/watch?v=DnozInAi1q0 https://pubs.acs.org/doi/10.1021/acs.inorgchem.8b00381	
Week 3	Preparation of silver wires.	https://pubs.rsc.org/en/content/articlelanding/2018/nr/c8nr02242a https://pubs.acs.org/doi/10.1021/acs.nanolett.0c01565	Class test/presentation/Assignments/Quizzer/ Viva/Project
Week 4	Preparation of magnetite/PS composite,	https://doi.org/10.1007/s13233-017-5065-1	
Week 5	Find the dielectric properties of multilayer composite material.	https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=853840 https://onlinelibrary.wiley.com/doi/full/10.1002/advs.202102221	
Week 6	Prepare core-shell type nanoparticles..	https://pubs.acs.org/doi/abs/10.1021/cr100449n https://pubs.rsc.org/en/content/articlelanding/2015/cs/c5cs00343a	
Week	Find the optical band	https://www.mdpi.com/2073-	

7	gap of $BaTiO3$ nanoparticles.	4360/14/21/4664	
Week 8	Study the effect of heating rate during calcination on the optical properties of BaTiO3.	https://doi.org/10.1007/s11082-022-04516-8	
Week 9	Study the effect of heating rate during calcination on the optical properties of BaTiO3.	https://doi.org/10.1007/s11082-022-04516-8	
Week 10	Find the X ray density of nanoparticles.	https://www.mdpi.com/2073-4360/14/21/4664	
Week 11	Data analysis and interpretation for all experiments.		
Week 12	Finalize reports and presentations for each experiment.		
Week 13	Review, discussion, and presentation of experimental findings.		

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Explain the principles of film growth and	(i) Each topic to be explained with illustrations. (ii)	• Presentations, quizzers and class discussions. •

	differentiate between various deposition techniques, such as solid state reaction method, coprecipitation method, and sol-gel films.	Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2	Comprehend the properties and applications of magnetic nanomaterials.		
3	Comprehend the properties and applications of dielectric nanomaterials.		
4	Identify and analyze real-world applications of nanomaterials in areas such as molecular electronics, nanoelectronics, catalysis, and photonic devices.		

UNS108	Characterization Techniques of Nanomaterials	L	T	P	C
Version 1.0		4	0	0	4
Total Contact Hours	60				
Pre-requisites/Exposure	Basic knowledge in Materials Science, Physics, Chemistry, Chemical Engineering, and Nanotechnology.				
Co-requisites					

Course Description

This course is an introduction to the principles of instrumental techniques for characterization of nanomaterials. This course aims at teaching the students underlying principles of analytical techniques that are commonly used for the evaluation of structural, morphological, optical, thermal, mechanical and electrical properties of nanomaterials.

Course Outcomes

- CO1: Identify and describe the various types of characterization techniques, including microscopy, spectroscopy, X-ray techniques, and methods for measuring mechanical, magnetic, electrical, and thermal properties of materials.
- CO2: Apply the knowledge learned to determine the appropriate characterization technique for a given material or situation.
- CO3: Synthesize the knowledge acquired from different characterization techniques to form a comprehensive understanding of the material's properties.
- CO4: Design an experiment utilizing one or more characterization techniques based on the material's properties and the information required.

Unit 1.15 Contact Hours

Basics of Characterization Techniques: Types of characterization techniques, Basics, Importance. Structural and compositional characterization tools, Difference between Microscopy and Spectroscopy, Optical Microscopy, Atomic Force Microscopy, Scanning Electron Microscopy, Transmission electron Microscopy, Scanning Tunneling Microscopy.

Unit 2. 15 Contact Hours

Spectroscopy: UV visible spectroscopy, Infrared Spectroscopy and Fourier Transform Infrared Spectroscopy, Raman Spectroscopy, Photoluminescence (PL), Photoelectron Spectroscopy (X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy & Ultra Violet Photoelectron Spectroscopy).

Unit 3. 10 Contact Hours

X-ray techniques: X-ray diffraction (XRD) technique, particle size determination using XRD, Applications of XRD, Electron diffraction and its application, neutron diffraction and its applications, X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy.

Unit 4. 20 Contact Hours

Mechanical, Magnetic, electrical and Thermal properties measurement: Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions, Hardness testing of thin films and coatings, Vibration Sample Magnetometer, Impedance Spectroscopy- PPMS, - Measurement of Magnetic and electrical properties of Nanomaterials, Dielectric constant measurement, Differential Thermal Analysis (DTA), Differential scanning calorimetry (DSC).

Reference Books

1. Elements of X-ray Diffraction B. D. Cullity, Addison Wesley, 1977
2. Transmission Electron Microscopy: A Textbook for Materials Science
   David B Williams, C Barry Carter, (1996) Plenum Press, New York
3. Impedance Spectroscopy: Theory, Experiment, and Applications,
   E. Barsoukov and J. Ross Macdonald (Editors) (2000) John Wiley & Sons (P)Ltd.
4. Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, (1995) CRC Press
5. Nanoindentation, By Anthony C Fischercripps, Anthony C. , Springer science and Bussiness media publications, 2011
6. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, Elsevier, 2009

Open Education Resources

- https://ocw.mit.edu/courses/materials-science-and-engineering/3-14-materials-laboratory-for-engineers-spring-2009/
- https://nanohub.org/
- https://phys.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy
- https://www.msm.cam.ac.uk/teaching/part-ii-courses/characterisation-materials
- https://www.merlot.org/merlot/viewMaterial.htm?id=637562
- https://www.khanacademy.org/science/physics/light-waves
- http://demonstrations.wolfram.com/XRayDiffractionOfCrystals/
- https://ncl.cancer.gov/resources/assay-cascade-protocols
- https://openstax.org/details/books/college-physics-ap-courses
- https://www.coursera.org/learn/material-behavior

Assessment & Evaluation

Components	Assignment	Mid Term	Attendance	End Term
Weightage (%)	20	20	10	50

Programme and Course Mapping

Course	Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
UNS108 Characterisation techniques of nanomaterials	CO1	3	2	2	1	2	1	1	2	1	1	3	2	2	2
	CO2	2	3	2	2	3	2	2	3	1	1	3	3	3	3
	CO3	2	2	3	2	3	2	2	3	1	1	3	3	3	3
	CO4	2	2	2	3	3	3	2	3	2	2	3	3	3	3

Lightly Mapped, 2=Moderately Mapped, 3=Strongly Mapped.

RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

Unit 1: Basics of Characterization Techniques

Indicator	Relevant Course Content
Local	-
Regional	-
National	-
Global	Microscopy techniques like optical microscopy and electron microscopy
Employability	practical skills in materials characterization using Microscopic techniques.
Entrepreneurship	innovation in materials technology.
Skill Development	materials science and characterization.
Professional Ethics	-

Gender	-
Human Values	
Environment & Sustainability	
SDG	responsible materials development in alignment with sustainability goals.
Nep 2020	Complies with the national education framework and curriculum guidelines.
Poe/4th IR	integration of advanced materials science into the evolving technological landscape.

Unit 2: Spectroscopy:

Indicator	**Relevant Course Content**
Local	-
Regional	-
National	-
Global	Spectroscopy techniques like UV-VIS spectroscopy, FTIR spectroscopy
Employability	practical skills in materials characterization using Spectroscopic techniques.
Entrepreneurship	innovation in materials technology.
Skill Development	materials science and characterization.
Professional Ethics	-
Gender	-
Human Values	
Environment & Sustainability	
SDG	responsible materials development in alignment with sustainability goals.
Nep 2020	Complies with the national education framework and curriculum guidelines.
Poe/4th IR	integration of advanced materials science into the evolving technological landscape.

Unit 3: X-ray techniques

Indicator	**Relevant Course Content**
Local	-
Regional	-

National	-
Global	X-Ray diffraction
Employability	practical skills in materials characterization using X-Ray techniques.
Entrepreneurship	innovation in materials technology.
Skill Development	materials science and characterization.
Professional Ethics	-
Gender	-
Human Values	
Environment & Sustainability	
SDG	responsible materials development in alignment with sustainability goals.
Nep 2020	Complies with the national education framework and curriculum guidelines.
Poe/4th IR	integration of advanced materials science into the evolving technological landscape.

Unit 4: Mechanical, Magnetic, electrical and Thermal properties measurement:

Indicator	**Relevant Course Content**
Local	-
Regional	-
National	-
Global	Properties measurement using UV-VIS spectroscopy, TGA, DSC, VSM etc.
Employability	practical skills in materials property measurement.
Entrepreneurship	innovation in materials technology.
Skill Development	materials science and characterization.
Professional Ethics	-
Gender	-
Human Values	
Environment & Sustainability	
SDG	responsible materials development in alignment with sustainability goals.
Nep 2020	Complies with the national education framework and curriculum guidelines.

Poe/4th IR	integration of advanced materials science into the evolving technological landscape.

Teaching Plan:

Week	*Topic*	*Reference Books/OER*	*Teaching/Learning Method*
1	*Introduction to Characterization Techniques*	*Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers,* [*https://ocw.mit.edu/courses/materials-science-and-engineering/3-14-materials-laboratory-for-engineers-spring-2009/*](https://ocw.mit.edu/courses/materials-science-and-engineering/3-14-materials-laboratory-for-engineers-spring-2009/)	*Lectures*
2	*Types of characterization techniques, Basics, Importance*	*Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers,* [*https://nanohub.org/*](https://nanohub.org/)	*Lectures and group discussions*
3	*Structural and compositional characterization tools*	*Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers,* [*https://www.msm.cam.ac.uk/teaching/part-ii-courses/characterisation-materials*](https://www.msm.cam.ac.uk/teaching/part-ii-courses/characterisation-materials)	*Lectures and lab exercises*
4	*Microscopy Techniques: Optical, Atomic Force, Scanning Electron*	*Transmission Electron Microscopy: A Textbook for Materials Science,* [*https://ncl.cancer.gov/resources/assay-cascade-protocols*](https://ncl.cancer.gov/resources/assay-cascade-protocols)	*Lectures and lab demonstrations*
5	*Transmission electron Microscopy and Scanning Tunneling*	*Transmission Electron Microscopy: A Textbook for Materials Science,* [*https://nanohub.org/*](https://nanohub.org/)	*Lectures and hands-on lab sessions*
6	*Introduction to Spectroscopy: UV visible spectroscopy*	*Fundamentals of Fourier Transform Infrared Spectroscopy,* *https://phys.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistr*	*Lectures and lab exercises*
7	*Infrared Spectroscopy and Fourier Transform Infrared Spectroscopy*	*Fundamentals of Fourier Transform Infrared Spectroscopy,* *https://phys.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistr*	*Lectures and lab exercises*

8	*Raman Spectroscopy, Photoluminescence (PL), Photoelectron*	*Impedance Spectroscopy: Theory, Experiment, and Applications, https://www.khanacademy.org/science/physics/light-waves*	*Lectures and hands-on lab sessions*
9	*Introduction to X-ray techniques: X-ray diffraction (XRD) technique*	*Elements of X-ray Diffraction, http://demonstrations.wolfram.com/XRayDiffractionOfCrystals/*	*Lectures and lab exercises*
10	*Particle size determination using XRD, Applications of XRD*	*Elements of X-ray Diffraction, http://demonstrations.wolfram.com/XRayDiffractionOfCrystals/*	*Lectures and group discussions*
11	*Electron diffraction and its application, neutron diffraction and its applications*	*Elements of X-ray Diffraction, http://demonstrations.wolfram.com/XRayDiffractionOfCrystals/*	*Lectures and hands-on lab sessions*
12	*Introduction to Measurement of Mechanical, Magnetic, electrical and*	*Nanoindentation, https://www.coursera.org/learn/material-behavior*	*Lectures and lab demonstrations*
13	*Nanoindentation principles, Hardness testing, Vibration Sample Magnetometer*	*Nanoindentation, Coursera – Material Behavior https://www.coursera.org/learn/material-behavior*	*Lectures and hands-on lab sessions*
14	*Measurement of Magnetic and electrical properties of Nanomaterials*	*Nanoindentation, Coursera – Material Behavio https://www.coursera.org/learn/material-behavior*	*Lectures and lab exercises*

Facilitating the Achievement of Course Learning Outcomes

Unit	Learning Outcome	Teaching/Learning Activity	Assessment Task

1.	Students will understand the types, basics, and importance of characterization techniques, and distinguish between microscopy and	Lecture on types of characterization techniques, labs for microscopy techniques.	Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
2.	Students will understand and apply the principles of various spectroscopy techniques (UV, IR, Raman, PL, and Photoelectron Spectroscopy).	Lecture on spectroscopy principles, labs for different spectroscopy techniques.	
3.	Students will understand and apply X-ray diffraction techniques, including particle size determination and applications of XRD, electron	Lecture on X-ray techniques, labs on XRD, electron diffraction, and neutron diffraction.	
4.	Students will comprehend the principles of measurement techniques for mechanical, magnetic, electrical and thermal properties.	Lecture on principles of property measurement, labs for hardness testing, impedance spectroscopy, dielectric	

UNS109	Characterization Techniques of Nanomaterials-I Lab	L	T	P	C
Version 1.0		0	0	2	1
Total Contact Hours	30				
Pre-requisites/Exposure	Basic knowledge in Materials Science, Physics, Chemistry, Chemical Engineering, and Nanotechnology.				
Co-requisites					

Course Description

This course is an introduction to the principles of instrumental techniques for characterization of nanomaterials. This course aims at teaching the students underlying principles of analytical techniques that are commonly used for the evaluation of structural, morphological, optical, thermal, mechanical and electrical properties of nanomaterials.

Course Outcomes

CO1: Evaluate and interpret structural and morphological properties of nanomaterials using X-Ray Diffraction and SEM/EDX/TEM techniques, demonstrating an ability to link these properties to material composition and structure.

CO2: Perform and interpret composition and thermal analysis of nanomaterials using FTIR spectroscopy and TGA/DSC, applying this understanding to infer material stability and transformations under thermal stress.

CO3: Apply UV-VIS spectrophotometry to study the optical properties of nanomaterials, focusing on determining the bandgap, and comprehend its impact on material performance in various applications.

CO4: Conduct and analyze mechanical property tests on nanomaterials through nanoindentation/hardness tests, using these outcomes to comprehend the relationship between material structure, composition, and mechanical performance.

List of Experiments

1. To analyse the structural properties such as crystallite size and lattice parameters using X-Ray Diffraction technique.
2. To study the morphological properties of nanomaterials using SEM/EDX/TEM.
3. To perform composition analysis using FTIR spectroscopy.
4. To Study thermal properties of nanomaterials using TGA/DSC.
5. To study the optical properties such as bandgap of a nanomaterial using UV-VIS spectrophotometer.
6. To study the mechanical properties of nanomaterials using nanoindentation/hardness test.

Reference Books

1. Elements of X-ray Diffraction B. D. Cullity, Addison Wesley, 1977
2. Transmission Electron Microscopy: A Textbook for Materials Science
David B Williams, C Barry Carter, (1996) Plenum Press, New York
3. Impedance Spectroscopy: Theory, Experiment, and Applications,
E. Barsoukov and J. Ross Macdonald (Editors) (2000) John Wiley & Sons (P)Ltd.
4. Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, (1995) CRC Press
5. Nanoindentation, By Anthony C Fischercripps, Anthony C. , Springer science and Bussiness media publications, 2011
6. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L.

Schodek, Paulo Ferreira, Michael F. Ashby, Elsevier, 2009

Open Education Resources

- https://www.youtube.com/watch?v=IeH0lhn7uHY&pp=ygV3VG8gYW5hbHlzZSB0aGUgc3RydWN0dXJhbCBwcm9wZXJ0aWVzIHN1Y2ggYXMgY3J5c3RhbGxpdGUgc2l6ZSBhbmQgbGF0dGljZSBwYXJhbWV0ZXJzIHVzaW5nIFgtUmF5IERpZmZyYWN0aW9uIHRlY2huaXF1ZS4%3D
- https://www.youtube.com/watch?v=ye-fdS4WS-Y&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D
- https://www.youtube.com/watch?v=QsQ-LYGt0fc&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D
- https://www.youtube.com/watch?v=eOPS2AAUwOU&pp=ygVAVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIEVEWA%3D%3D
- https://www.youtube.com/watch?v=XBsiH9_R4hQ&pp=ygU4VG8gcGVyZm9ybSBjb21wb3NpdGlvbiBhbmFseXNpcyB1c2luZyBGVElSIHNwZWN0cm9zY29weS4%3D
- https://www.youtube.com/watch?v=nZ0d9za2YCs&pp=ygVhVG8gc3R1ZHkgdGhlIG9wdGljYWwgcHJvcGVydGllcyBzdWNoIGFzIGJhbmRnYXAgb2YgYSBuYW5vbWF0ZXJpYWwgdXNpbmcgVVYtVklTIHNwZWN0cm9waG90b21ldGVyLg%3D%3D
- https://www.youtube.com/watch?v=gjqG-voAems&pp=ygVYVG8gc3R1ZHkgdGhlIG1lY2hhbmljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIG5hbm9pbmRlbnRhdGlvbi9oYXJkbmVzcyB0ZXN0Lg%3D%3D

Assessment & Evaluation

Components	Conduct of Experiment	Lab Record/Viva Voce	Attendance	End Term Examination
Weightage (%)	20	20	10	50

Programme and Course Mapping

C ou	CO/ PO	P O1	P O2	P O3	P O4	P O5	P O6	P O7	P O8	P O9	PO 10	PS O1	PS O2	PS O3	PS O4
z	CO1	2	2	1	2	2	3	2	3	1	1	3	2	2	2
	CO2	2	3	2	2	2	3	2	3	1	1	3	2	3	2
	CO3	2	3	2	2	2	3	2	3	1	1	3	2	3	3
	CO4	2	2	1	2	3	3	2	3	1	1	3	2	3	3

RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

Indicator	Relevant Course Content
Local	-
Regional	-
National	-
Global	Characterisation techniques I.e. XRD, FTIR, SEM, TEM
Employability	practical skills in materials characterization
Entrepreneurship	innovation in materials technology.
Skill Development	materials science and characterization.
Professional Ethics	-
Gender	-
Human Values	
Environment & Sustainability	
SDG	responsible materials development in alignment with sustainability goals.
Nep 2020	Complies with the national education framework and curriculum guidelines.
Poe/4th IR	integration of advanced materials science into the evolving technological landscape.

Teaching Plan:

Week	Topics	Reference Books/Open Educational Resources	Teaching-Learning Method
1	Introduction to X-Ray Diffraction	Elements of X-ray Diffraction B. D. Cullityhttps://www.youtube.com/watch?v=IeH0lhn7uHY&pp=ygV3VG8gYW5hbHlzZSB0aGUgc3RydWN0dXJhbCBwcm9wZXJ0aWVzIHN1Y2ggYXMgY3J5c3RhbGxpdGUgc2l6ZSBhbmQgbGF0dGljZSBwYXJhbWV0ZXJzIHVzaW5nIFgtUmF5IERpZmZyYWN0aW9uIHRlY2huaXF1ZS4%3D	Lecture, Group Discussion
2	In-depth understanding of X-Ray Diffraction	Elements of X-ray Diffraction B. D. Cullity, https://www.youtube.com/watch?v=IeH0lhn7uHY&pp=ygV3VG8gYW5hbHlzZSB0aGUgc3RydWN0dXJhbCBwcm9wZXJ0aWVzIHN1Y2ggYXMgY3J5c3RhbGxpdGUgc2l6ZSBhbmQgbGF0dGljZSBwYXJhbWV0ZXJzIHVzaW5nIFgtUmF5IERpZmZyYWN0aW9uIHRlY2huaXF1ZS4%3D	Lecture, Practical Session
3	SEM/EDX/TEM: Basic Concepts	Transmission Electron Microscopy: A Textbook for Materials Science, David B Williams, C Barry Carter, https://www.youtube.com/watch?v=ye-fdS4WS-Y&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D https://www.youtube.com/watch?v=QsQ-LYGt0fc&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D https://www.youtube.com/watch?v=eOPS2AAUwOU&pp=ygVAVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIEVEWA%3D%3D	Lecture, Practical Session
4	Advanced study of SEM/EDX/TEM	Transmission Electron Microscopy: A Textbook for Materials Science, David B Williams, C Barry Carter https://www.youtube.com/watch?v=ye-fdS4WS-Y&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D https://www.youtube.com/watch?v=QsQ-LYGt0fc&pp=ygVJVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIFNFTS9FRFgvVEVNLg%3D%3D https://www.youtube.com/watch?v=eOPS2AAUwOU&pp=ygVAVG8gc3R1ZHkgdGhlIG1vcnBob2xvZ2ljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIEVEWA%3D%3D	Lecture, Practical Session

		GVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIEVEWA%3D%3D	
5	Introduction to FTIR Spectroscopy	Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, https://www.youtube.com/watch?v=XBsiH9_R4hQ&pp=ygU4VG8gcGVyZm9ybSBjb21wb3NpdGlvbiBhbmFseXNpcyB1c2luZyBGVElSIHNwZWN0cm9zY29weS4%3D	Lecture, Group Discussion
6	In-depth understanding of FTIR Spectroscopy	Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, https://www.youtube.com/watch?v=XBsiH9_R4hQ&pp=ygU4VG8gcGVyZm9ybSBjb21wb3NpdGlvbiBhbmFseXNpcyB1c2luZyBGVElSIHNwZWN0cm9zY29weS4%3D	Lecture, Practical Session
7	Midterm Review and Examination	All References	Review, Examination
8	TGA/DSC: Basic Concepts	Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, https://www.youtube.com/watch?v=bENSsj4rfJc&pp=ygU7VG8gU3R1ZHkgdGhlcm1hbCBwcm9wZXJ0aWVzIG9mIG5hbm9tYXRlcmlhbHMgdXNpbmcgVEdBL0RTQy4%3D	Lecture, Group Discussion
9	Advanced study of TGA/DSC	Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby,https://www.youtube.com/watch?v=bENSsj4rfJc&pp=ygU7VG8gU3R1ZHkgdGhlcm1hbCBwcm9wZXJ0aWVzIG9mIG5hbm9tYXRlcmlhbHMgdXNpbmcgVEdBL0RTQy4%3D	Lecture, Practical Session
10	Introduction to UV-VIS Spectrophotometry	Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, https://www.youtube.com/watch?v=nZ0d9za2YCs&pp=ygVhVG8gc3R1ZHkgdGhlIG9wdGljYWwgcHJvcGVydGllcyBzdWNoIGFzIGJhbmRnYXAgb2YgYSBuYW5vbWF0ZXJpYWwgdXNpbmcgVVYtVklTIHNwZWN0cm9waG90b21ldGVyLg%3D%3D	Lecture, Group Discussion
11	In-depth understanding of UV-VIS Spectrophotometry	Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, https://www.youtube.com/watch?v=nZ0d9za2YCs&pp=ygVhVG8gc3R1ZHkgdGhlIG9wdGljYWwgcHJvcGVydGllcyBzdWNoIGFzIGJhbmRnYXAgb2YgYSBuYW5vbWF0ZXJpYWwgdXNpbmcgVVYtVklTIHNwZWN0cm9waG90b21ldGVyLg%3D%3DdG	Lecture, Practical Session

		VyLg%3D%3D	
12	Introduction to Nanoindentation/hardness test	Nanoindentation, By Anthony C Fischercripps, https://www.youtube.com/watch?v=gjqG-voAems&pp=ygVYVG8gc3R1ZHkgdGhlIG1lY2hhbmljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIG5hbm9pbmRlbnRhdGlvbi9oYXJkbmVzcyB0ZXN0Lg%3D%3D	Lecture, Group Discussion
13	In-depth understanding of Nanoindentation/hardness test	Nanoindentation, By Anthony C Fischercripps, https://www.youtube.com/watch?v=gjqG-voAems&pp=ygVYVG8gc3R1ZHkgdGhlIG1lY2hhbmljYWwgcHJvcGVydGllcyBvZiBuYW5vbWF0ZXJpYWxzIHVzaW5nIG5hbm9pbmRlbnRhdGlvbi9oYXJkbmVzcyB0ZXN0Lg%3D%3D	Lecture, Practical Session
14	Review of all Topics and Final Examination Preparation	All References	Review, Examination Preparation

Facilitating the Achievement of Course Learning Outcomes

Learning Outcomes	Teaching & Learning Activities	Assessment Methods
Evaluate and interpret structural properties of nanomaterials, with an understanding of crystallite size and lattice parameters.	Lectures on the principles and applications of X-ray diffraction, followed by laboratory experiments.	Presentations and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
Perform and interpret composition and morphological analysis of nanomaterials, linking these properties to material composition and structure.	Lectures on the theory and practical aspects of SEM/EDX/TEM and FTIR, with subsequent practical sessions in the lab.	
Analyze the thermal and optical properties of nanomaterials, understanding material stability under thermal stress and the concept of bandgap.	Lectures on the principles and uses of TGA/DSC and UV-VIS Spectrophotometry, followed by lab experiments.	

Assess the mechanical properties of nanomaterials, understanding the link between material structure, composition, and mechanical performance.	Lectures on the principles and applications of nanoindentation/hardness tests, followed by lab experiments.	

UNS110	Synthesis of Nanomaterials-II	L	T	P	C
Version 1.0		4	0	0	4
Total Contact Hours	60				
Pre-requisites/Exposure	Basics of Nanomaterial				
Co-requisites	--				

Course Objectives:

1. Understand the fundamental principles of thin film growth and the various techniques used in the fabrication of two-dimensional nanostructures.
2. Explore the unique properties of special nanomaterials, such as carbon fullerenes, nanotubes, mesoporous structures, and organic-inorganic hybrids.
3. Familiarize students with the fabrication processes and characterization techniques used in creating nanostructures through physical techniques like lithography and nanomanipulation.
4. Gain insight into the diverse applications of nanomaterials, including molecular electronics, nanoelectronics, catalysis, photonic crystals, and biological applications.

Course Outcomes:

CO1 Students will be able to explain the principles of film growth and differentiate between various deposition techniques, such as PVD, CVD, ALD, and sol-gel films.

CO2 Students will comprehend the properties and applications of carbon fullerenes, nanotubes, ordered and random mesoporous structures, and other special nanomaterials.

CO3 Students will acquire practical skills in lithography and nanomanipulation techniques like STM, AFM, and soft lithography for nanostructure fabrication.

CO4 Students will be able to identify and analyze real-world applications of nanomaterials in areas such as molecular electronics, nanoelectronics, catalysis, and photonic devices.

CATALOG DESCRIPTION

This course introduces the fundamentals of nanostructures, including their synthesis, characterization, and applications. Topics covered include thin films, carbon nanotubes, mesoporous structures, and quantum devices. A background in physics, chemistry, or materials science is recommended. Upon completion of this course, students will be able to: Understand the basic principles of nanostructure synthesis and characterization, apply these principles to the design and fabrication of nanostructures.

Course Content

UNIT-I **15 Lectures**

Two-Dimensional Nanostructures: Thin Films

Introduction; Fundamentals of Film Growth; Vacuum Science; Physical Vapor Deposition (PVD): (Evaporation, Molecular beam epitaxy (MBE), Sputtering, Comparison of evaporation and sputtering); Chemical Vapor Deposition (CVD):(Typical chemical reactions,Reactionkinetics,Transport phenomena,5CVD methods,Diamond films by CVD);
Atomic Layer Deposition (ALD); Superlattices; Self-Assembly:(Monolayers of organosilicon or alkylsilane derivatives, Monolayers of alkanethiols and sulfides, Monolayers of carboxylic acids, amines alkylsilanederivativesand alcohols); Langmuir-Blodgett Films; Electrochemical Deposition; Sol-Gel Films

UNIT-II **15 Lectures**

Special Nanomaterials

Introduction; Carbon Fullerenes and Nanotubes (Carbon fullerenes,Fullerene-derived crystals, Carbon nanotubes); Ordered mesoporous structures; Random mesoporous structures; Crystalline microporous materials: zeolites; Metal-oxide structures; Metal-polymer structures; Oxide-polymer structures; Organic-Inorganic Hybrids :(Class I hybrids, Class II hybrids);Intercalation Compounds; Nanocomposites and Nanograined Materials;

UNIT-III **15 Lectures**

Nanostructures Fabricated by Physical Techniques

Introduction;Lithography:(Photolithography,Phase-shifting photolithography, Electron beam lithography,X-ray lithography,Focused ion beam (FIB) lithography,Neutral atomic beam lithography); Nanomanipulation and Nanolithography : (Scanning tunneling microscopy (STM), Atomic force microscopy (AFM) ,Near-field scanning optical microscopy (NSOM) ,Nanomanipulation,Nanolithography); Soft Lithography: (Microcontact printing, Molding, Nanoimprint, Dip-pen nanolithography); Assembly of Nanoparticles and Nanowires: (Capillary forces, Dispersion interactions, Shear force assisted assembly, Electric-field assisted assembly, Covalently linked assembly, Gravitational field assisted assembly, Template-assisted assembly); Other Methods for Microfabrication

UNIT IV **15 Lectures**

Applications of Nanomaterials

Introduction;Molecular Electronics and Nanoelectronics;Nanobots; Biological Applications of Nanoparticles; Catalysis by Gold Nanoparticles; Band Gap Engineered Quantum Devices: (Quantum well devices, Quantum dot devices);Nanomechanics;Carbon Nanotube Emitters; Photoelectrochemical Cells; Photonic Crystals and Plasmon Waveguides: (Photonic crystals,Plasmon waveguides)

Suggested Text Books

1 Nanostructures and Nanomaterials: Synthesis, Properties andApplications, G, Cao, Imperial College Press (2003).

Advanced Readings:

1. Nanoscale Science and Technology , Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons Ltd (2005).

2. Nanomaterials and Nanochemistry, C. Brechignac, P. Houdy, M. Lahmani, Springer-Verlag Berlin Heidelberg (2007).

3 Introduction to Nanoscale Science and Technology, Massimiliano Di Ventra, StephaneEvoy and James R. Heflin, Jr., Kluwer Academic Publishers (2004)

4. Springer handbook of nanotechnology , Bharat Bhushan (ed.) Spinger-Verlag Berlin Heidelberg New York (2004),

Open Educational Resources (OER)

https://news.mit.edu/2015/explained-chemical-vapor-deposition-0619
https://www.nanowerk.com/nanotechnology/introduction/introduction_to_nanotechnology_22.php
https://www.youtube.com/watch?v=aOVU2aqgqe8
https://www.youtube.com/watch?v=dw9IvpilfUo
https://www.youtube.com/watch?v=1WGEMYDLsNs
https://en.wikipedia.org/wiki/Nanocomposite#:~:text=Nanocomposite%20is%20a%20multiphase%20solid,that%20make%20up%20the%20material.

Assessment & Evaluation

Components	**Quiz/Presentation / Assignment**	**Mid Term Examination**	**Attendance**	**End Term Examination**
Weightage (%)	**20**	**20**	**10**	**50**

ProgrammeAnd Course Mapping

Course Outcome (CO)	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	2	1	1	1	1	1	1	1	1	2	1	1	1
CO2	1	2	1	2	2	1	1	1	1	1	2	2	1	1
CO3	1	1	3	3	1	3	1	3	1	1	1	3	1	1
CO4	1	2	1	3	1	1	1	1	1	1	1	3	1	1

The numbers 1, 2, and 3 represent 1="lightly mapped," 2="moderately mapped," and 3="strongly mapped,"

RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

Unit i	Two-Dimensional Nanostructures: Thin Films
Local	Enhancing local industries with advanced thin film technologies.
Regional	Contributing to regional growth in electronics, surface treatments, and material science research.
National	Supporting national industries in electronics, advanced materials, and research & development.
Global	Aligning with global electronics & communications market trends and technological advancements.
Employability	Preparing students for careers as thin film technologists, surface engineers, or researchers in the field.
Entrepreneurship	Enabling entrepreneurial ventures in nano-film production and advanced surface treatments.
Skill development	Developing skills in film growth, PVD, CVD, ALD techniques, and thin film characterization methods.
Professional ethics	Promoting ethical methods in nano-film production, material sourcing, and laboratory practices.
Gender	Encouraging gender diversity in nanotechnology roles through equal opportunities.
Human values	Emphasizing the responsible use of nanotechnology for the betterment of society.
Environment & sustainability	Promoting eco-friendly methodologies and waste reduction in thin film production.
Unit ii	Special Nanomaterials

Local	-Enhancing local materials and electronics sectors with specialized nanomaterials like carbon fullerenes, nanotubes, and ordered mesoporous structures.
Regional	- Contributing to regional academic and industrial research capabilities in material science, electronics, and advanced materials.
National	Supporting national advancements in material science, electronics, and research & development sectors.
Global	Aligning with global trends in research and development of specialized nanomaterials, encouraging international collaborations.
Employability	-Providing career opportunities in electronics, materials science, and R&D roles with expertise in specialized nanomaterials.
Entrepreneurship	Fostering entrepreneurial ventures in the production and research of advanced nanomaterials.
Skill development	Developing skills in the synthesis and characterization of specialized nanomaterials like carbon fullerenes, nanotubes, and mesoporous structures.
Professional ethics	Promoting ethical practices in material sourcing, research, and responsible handling of advanced nanomaterials.
Gender	Encouraging gender diversity in material science research and applications, ensuring equal opportunities.
Human values	Emphasizing the responsible and ethical use of specialized nanomaterials for societal benefits.
Environment & sustainability	Encouraging eco-friendly practices in the synthesis and application of specialized nanomaterials.
Unit iii	Nanostructures Fabricated by Physical Techniques

Local	Strengthening local research institutions and industries with knowledge of advanced fabrication techniques like lithography, nanomanipulation, and nanolithography.
Regional	Enhancing regional research and industrial capabilities in microfabrication, advanced materials, and surface science.
National	Contributing to national advancements in microfabrication, electronics, and nanotechnology research sectors.
Global	Aligning with global trends in microfabrication techniques, fostering international research collaborations.
Employability	Providing career opportunities in research and development, electronics manufacturing, and microfabrication industries.
Entrepreneurship	Enabling entrepreneurial ventures in microfabrication and advanced material production using techniques such as soft lithography and nanomanipulation.
Skill development	Developing practical skills in lithography, nanolithography, and nanomanipulation, essential for microfabrication and material research.
Professional ethics	Emphasizing ethical practices in research, laboratory work, and responsible handling of advanced materials.
Gender	Encouraging gender diversity in material science research and microfabrication roles.
Human values	Promoting the responsible and ethical use of advanced fabrication techniques for societal benefits.
Environment & sustainability	Encouraging eco-friendly practices in microfabrication, including waste reduction and sustainable materials.
Unit iv	Applications of Nanomaterials

Local	Enhancing local research institutions and industries with applications in molecular electronics, nanobots, and advanced materials.
Regional	Contributing to regional technological advancements in electronics, biotechnology, and nanomechanics.
National	Supporting national innovation in electronics, biotechnology, and materials science, driving economic growth.
Global	Aligning with global trends in nanoelectronics, biotechnological applications, and quantum devices.
Employability	Preparing students for diverse career opportunities in nanoelectronics, biotechnology, catalysis, and advanced material applications.
Entrepreneurship	Fostering entrepreneurial ventures in nanotechnology applications, molecular electronics, and advanced material innovations.
Skill development	Developing skills in the practical application of nanomaterials in diverse sectors like electronics, medicine, and energy.
Professional ethics	Emphasizing ethical considerations in the application of nanomaterials, ensuring safety, and responsible practices.
Gender	Encouraging gender diversity in nanotechnology applications and research, ensuring equal opportunities for all.
Human values	Promoting the responsible and ethical application of nanomaterials for the betterment of society.
Environment & sustainability	Encouraging sustainable practices in the application of nanomaterials, including eco-friendly energy solutions and biodegradable materials.
SDG	Supporting SDG goals like Goal 3 (Good Health and Well-being), Goal 7 (Affordable and Clean Energy), Goal 9 (Industry, Innovation, and Infrastructure), and Goal 11 (Sustainable Cities and Communities) through diverse applications of nanomaterials.

Nep 2020	Aligning with the National Education Policy's emphasis on multidisciplinary education, application-based learning, and critical thinking.
Poe/4th IR	Preparing students for the Fourth Industrial Revolution with knowledge of applications of nanomaterials in the age of cyber-physical systems, IoT, and biotechnological advancements.

Teaching Plan

Weekly Teaching Plan	Topic/Unit No.	Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education Resources [OER]	Teaching-Learning Method
Week 1	Introduction to Two-Dimensional Nanostructures: Thin Films,Fundamentals of Film Growth,Vacuum Science and Importance in Thin Film Deposition	TB1/CH5	Class test/presentation/Assignments/Quizzer/Viva/Project Class test/presentation/Assignments/Quizzer/Viva/Project
Week 2	Physical Vapor Deposition (PVD) Techniques: Evaporation.Molecular Beam Epitaxy (MBE) and its Applications,	https://www.youtube.com/watch?v=aOVU2aqgqe8 TB1/CH5	
Week 3	Sputtering Technique and Comparison with Evaporation, Introduction to Chemical Vapor Deposition (CVD) and its Basics	TB1/CH5 https://news.mit.edu/2015/explained-chemical-vapor-deposition-0619	
Week 4	Typical Chemical Reactions in CVD, Reaction Kinetics and Transport Phenomena in CVD, Different CVD Methods and their Advantages/Disadvantages	TB1/CH5	
Week 5	Diamond Films by Chemical Vapor Deposition (CVD), Introduction to Atomic Layer Deposition (ALD) and its Mechanism	TB1/CH5	
Week 6	Langmuir-Blodgett Films: Preparation and Characterization, Electrochemical Deposition of Nanostructures	TB1/CH5	

Week 7	superlattices: Fabrication and Properties, Self-Assembly of Nanostructures: Monolayers and their Applications	TB1/CH5	
Week 8	Sol-Gel Films: Synthesis and Applications, Introduction to Special Nanomaterials	TB1/CH5	
Week 9	Carbon Fullerenes: Structure and Properties, Carbon Nanotubes: Types and Applications	TB1/CH6 RB4/CH3 https://www.nanowerk.com/nanotechnology/introduction/introduction_to_nanotechnology_22.php RB3.CH4-6	
Week 10	Ordered and Random Mesoporous Structures, Crystalline Microporous Materials: Zeolites and their Uses	TB1/CH6 https://www.youtube.com/watch?v=1WGEMYDLsNs https://www.youtube.com/watch?v=1WGEMYDLsNs	
Week 11	Metal-Oxide Structures: Synthesis and Properties, Metal-Polymer and Oxide-Polymer Nanocomposites	TB1/CH6	
Week 12	Organic-Inorganic Hybrids: Class I and Class II Hybrids, Intercalation Compounds and their Applications	TB1/CH6	
Week 13	Nanostructures Fabricated by Physical Techniques, Lithography Techniques: Photolithography, Electron Beam Lithography, and more	TB1/CH7 https://www.youtube.com/watch?v=dw9IvpilfUo RB3/CH1	

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching Learning Activity	Assessment Task Methods
1	Learn how to fabricate thin films	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged	• Presentations, quizzers and class discussions. • Assignments and class
2	Students will comprehend		

	the properties and applications of special nanomaterials like grapheme, CNT etc	to discover the relevant concepts. (iii) Students be given homework/assignments. (iv) Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce examinations. • End-term examinations.
3	Students will acquire practical skills in lithography and nanomanipulation techniques.		
4	Students will be able to identify and analyze real-world applications of nanomaterials		

UNS111	Synthesis of Nanomaterials-II Lab	L	T	P	C
Version 1.0		0	0	2	1
Total Contact Hours	26				
Pre-requisites/Exposure					
Co-requisites	Synthesis of Nanomaterials				

Course Objectives:

1. Understand the fundamental principles of thin film growth and the various techniques used in the fabrication of two-dimensional nanostructures.
2. Explore the unique properties of special nanomaterials, such as carbon fullerenes, nanotubes, mesoporous structures, and organic-inorganic hybrids.
3. Familiarize students with the fabrication processes and characterization techniques used in creating nanostructures through physical techniques like lithography and nanomanipulation.
4. Gain insight into the diverse applications of nanomaterials, including molecular electronics, nanoelectronics, catalysis, photonic crystals, and biological applications.

Course Outcomes:

CO1	Students will be able to explain the principles of film growth and differentiate between various deposition techniques, such as solid state reaction method, coprecipitation method, and sol-gel films.
CO2	Students will comprehend the properties and applications of magneticlnanomaterials.
CO3	Students will comprehend the properties and applications of dielectric nanomaterials.
CO4	udents will be able to identify and analyze real-world applications of nanomaterials in areas such as molecular electronics, nanoelectronics, catalysis, and photonic devices.

CATALOG DESCRIPTION

This course introduces the fundamentals of nanostructures, including their synthesis, characterization, and applications. Topics covered include thin films, carbon nanotubes, mesoporous structures, and quantum devices. A background in physics, chemistry, or materials science is recommended. Upon completion of this course, students will be able to: Understand the basic principles of nanostructure synthesis and characterization, apply these principles to the design and fabrication of nanostructures.

Course Content

1, Preparation of Polystyrene film using solvent evaporation technique.
2. Preparation of magnetite particles using coprecipitation method.
3. Preparation of ferrofluid using water and magnetite particles,
4 Study the stability of magnetite particles in water and vegetable oil.
5. Prepare calcium titanate using solid state reaction method.
6 Find the opticle band gap of magnetite particles.
7. Make pallet of calcium titanate powder, sinter and polish.
8. Find the density of pallet using Archimedes principle.

<u>Suggested Text Books</u>

1 Nanostructures and Nanomaterials: Synthesis, Properties andApplications, G, Cao, Imperial College Press (2003).

Advanced Readings:

1. Nanoscale Science and Technology , Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons Ltd (2005).
2. Nanomaterials and Nanochemistry, C. Brechignac, P. Houdy, M. Lahmani, Springer-Verlag Berlin Heidelberg (2007).
3 Introduction to Nanoscale Science and Technology, Massimiliano Di Ventra, StephaneEvoy and James R. Heflin, Jr., Kluwer Academic Publishers (2004)
4. Springer handbook of nanotechnology , Bharat Bhushan (ed.) Spinger-Verlag Berlin Heidelberg New York (2004),

Open Educational Resources (OER)

https://doi.org/10.1021/ma001440d
https://pubs.acs.org/doi/abs/10.1021/ma000094x
https://www.sciencedirect.com/science/article/abs/pii/S0927775708000721
https://www.sciencedirect.com/science/article/abs/pii/S0167577X08005740
https://pubs.acs.org/doi/abs/10.1021/ed076p943
https://www.sciencedirect.com/science/article/abs/pii/S0304885305011406
https://www.sciencedirect.com/science/article/abs/pii/S0021979705004935
https://www.sciencedirect.com/science/article/abs/pii/S0021979705005515
https://doi.org/10.1063/1.108974
https://link.springer.com/article/10.1007/s10853-006-0103-y
https://www.youtube.com/watch?v=4q9Bh48RTxg
https://www.youtube.com/watch?v=YpbNyDzpB3A

Assessment & Evaluation

Components	**Conduct of Experiment**	**Lab Record/Viva Voce**	**Attendance**	**End Term Examination**
Weightage (%)	**20**	**20**	**10**	**50**

ProgrammeAnd Course Mapping

Course Outcome (CO)	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO4**

CO1	2	2	1	1	1	1	1	1	1	1	2	1	1	1
CO2	1	2	1	2	2	1	1	1	1	1	2	2	1	1
CO3	1	1	3	3	1	3	1	3	1	1	1	3	1	1
CO4	1	2	1	3	1	1	1	1	1	1	1	3	1	1

1, 2, and 3 represent 1="lightly mapped," 2="moderately mapped," and 3="strongly mapped,"

RELEVANCE OF THE COURSE TO VARIOUS INDICATORS

Unit	Course Content
Local	Supports local industries in materials development and advanced fabrication methods, fostering innovation.
Regional	Augments regional academic and industrial capabilities in materials science, enhancing tech-based development.
National	Contributes to the nation's technological progress, especially in material science and advanced manufacturing sectors.
Global	Aligns with global material science trends, fostering international collaborations and technology integration.
Employability	Equips students for roles in materials science, R&D, manufacturing, and nanotechnology industries.
Entrepreneurship	Enables startups in advanced material manufacturing, nanotechnology, and applied research.
Skill development	Imparts hands-on skills in material preparation, characterization, and advanced fabrication methods.
Professional ethics	Advocates for responsible material sourcing, ethical research practices, and safe laboratory protocols.
Gender	Promotes inclusivity in material science research, fostering equal

	opportunities regardless of gender.
Human values	Emphasizes ethical use of knowledge for societal benefits, considering the broader societal implications and benefits.
Environment & sustainability	Stresses eco-friendly practices in material synthesis, promoting sustainability and aligning with SDG goals.
SDG	Supporting SDG goals like Goal 3 (Good Health and Well-being), Goal 7 (Affordable and Clean Energy), Goal 9 (Industry, Innovation, and Infrastructure), and Goal 11 (Sustainable Cities and Communities) through diverse applications of nanomaterials.
Nep 2020	Aligns with India's National Education Policy's focus on practical knowledge, research, and innovative applications.
Poe/4th IR	Prepares for the Fourth Industrial Revolution with expertise in advanced materials and nanotechnology, essential for emerging tech sectors.

Teaching Plan

Weekly Teaching Plan	**Topic/Unit No.**	**Textbook [TB]/ Reference Book [RB]-Chapter/ Page No./ Open Education**	**Teaching-Learning Method**
Week 1	Introduction to laboratory safety procedures and overview of the experiments.	TB1/CH5	Class test/presentation /Assignments/Quizzer/ Viva/Project
Week 2	Experiment 1: Preparation of Polystyrene film using solvent evaporation technique.	https://doi.org/10.1021/ma001440d https://pubs.acs.org/doi/abs/10.1021/ma000094x	Class test/presentation /Assignments/Quizzer/ Viva/Project
Week 3	Experiment 2: Preparation of magnetite particles using coprecipitation method.	https://www.sciencedirect.com/science/article/abs/pii/S0927775708000721 https://www.sciencedirect.com/science/article/abs/pii/S0304885305005433 https://www.sciencedirect.com/science/	

		article/abs/pii/S0167577X08005740	
Week 4	Experiment 3: Preparation of ferrofluid using water and magnetite particles.	https://pubs.acs.org/doi/abs/10.1021/ed076p943 https://www.sciencedirect.com/science/article/abs/pii/S0304885305011406	
Week 5	Experiment 4: Study the stability of magnetite particles in water and vegetable oil.	https://www.sciencedirect.com/science/article/abs/pii/S0021979705004935 https://www.sciencedirect.com/science/article/abs/pii/S0021979705005515	
Week 6	Experiment 5: Prepare calcium titanate using solid state reaction method.	https://doi.org/10.1063/1.108974 https://link.springer.com/article/10.1007/s10853-006-0103-y	
Week 7	Experiment 6: Find the optical band gap of magnetite particles.	https://doi.org/10.1016/j.jallcom.2023.170811	
Week 8	Experiment 7: Make pallet of calcium titanate powder, sinter, and polish.	https://fluxana.com/images/Whitepaper/PDF/Whitepaper_Making_Pressed_Pellets.pdf https://patents.google.com/patent/US4260349 https://www.youtube.com/watch?v=o8nok8N5eso	
Week 9	Experiment 7: Continue pallet preparation and sintering process.	https://fluxana.com/images/Whitepaper/PDF/Whitepaper_Making_Pressed_Pellets.pdf	

		https://patents.google.com/patent/US4260349 https://www.youtube.com/watch?v=o8nok8N5eso	
Week 10	Experiment 8: Find the density of pallet using Archimedes principle.	https://www.youtube.com/watch?v=4q9Bh48RTxg https://www.youtube.com/watch?v=YpbNyDzpB3A	
Week 11	Data analysis and interpretation for all experiments.		
Week 12	Finalize reports and presentations for each experiment.		
Week 13	Review, discussion, and presentation of experimental findings.		

Facilitating the Achievement of Course Learning Outcomes

Unit No.	**Course Learning Outcomes**	**Teaching Learning Activity**	**Assessment Task Methods**
1	Explain the principles of film growth and differentiate between various deposition techniques for thin films.	(i) Each topic to be explained with illustrations. (ii) Students to be encouraged to discover the relevant concepts. (iii) Students be given homework/assignments. (iv)	• Presentations, quizzers and class discussions. • Assignments and class tests. • Student presentations. • Mid-term examinations. • Practical and viva-voce
2	Understand the properties and applications of magnetic nanomaterials.		

3	Understand the properties and applications of dielectric nanomaterials.	Discuss and solve the theoretical and practical problems in the class. (v) Students to be encouraged to apply concepts to real world problems.	examinations. • End-term examinations.
4	Identify, analyze, and relate real-world applications of nanomaterials in areas like molecular electronics, nanoelectronics, catalysis, and photonic devices.		